

BELL & HOWELL SCHOOLS

ASSEMBLY MANUAL 9550-2
Part 1
Digital Multimeter

595-1666-06

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Sincerely,

HEATH COMPANY
Benton Harbor, Michigan 49022

Prices and specifications subject to change without notice.

Assembly Manual

for the



DIGITAL MULTIMETER

9550-2, Part 1

CONTINUED FROM 9550-1

Keep your first Assembly Manual with this Manual and refer to it about any assembly questions. The procedures outlined in the first Manual will also apply to the steps contained in this Manual.

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PARTS LIST

Unpack all parts. Then identify each part called out on the following list and Parts Pictorials on fold-outs from this page and Page 2-4.

KEY No.	PART No.	PARTS Per Kit	DESCRIPTION	PRICE Each
RESISTORS, 5%				
(X)	A1 1-124	1	27 k Ω (red-violet-orange-gold)	.15
(X)	A1 1-101	1	1 M Ω (brown-black-green-gold)	.15
Precision				
(X)	A2 3-25-5	1	1 Ω , 5-watt, 1%	1.35
(X)	A2 2-47-1	1	10 Ω , 1-watt, .5%	1.00
(X)	A2 2-4	1	100 Ω , 1/2-watt, .5%	1.05
(X)	A2 2-6	1	1000 Ω (1 k), 1/2-watt, .5%	1.00
(X)	A2 2-670-12	1	1010 Ω , (1.01 k), 1/4-watt, .5%	1.15
(X)	A2 2-17-12	1	9090 Ω (9.09 k), 1/4-watt, .1%	.70
(X)	A2 2-294	1	90.9 k Ω , 1/2-watt, .5%	1.00
(X)	A2 2-98-1	1	909 k Ω , 1-watt, .5%	2.40

TRANSISTORS

NOTE: Transistors and integrated circuits are marked for identification in one of the following four ways:

1. Part number.
2. Type number.
3. Part number and type number.
4. Part number with a type number other than the one listed.

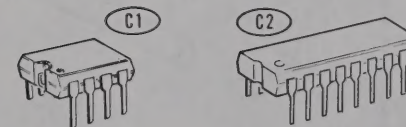
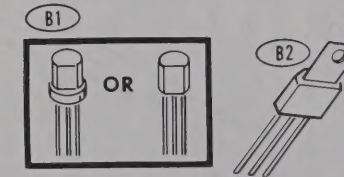
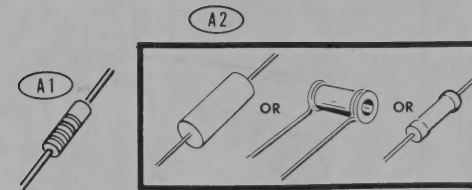
KEY No.	PART No.	PARTS Per Kit	DESCRIPTION	PRICE Each
Transistors (cont'd.)				
(X)	B1 417-234	3	2N3638A transistor	.60
(X)	B1 417-134	4	MPS6520 transistor	1.05
(X)	B1 417-291	2	2N5458 transistor	1.10
(X)	B1 417-294	2	MPSA42 transistor	.75
(X)	B1 417-801	4	MPSA20 transistor	.25
(X)	B2 417-272	1	D40C1 transistor	1.60

INTEGRATED CIRCUITS

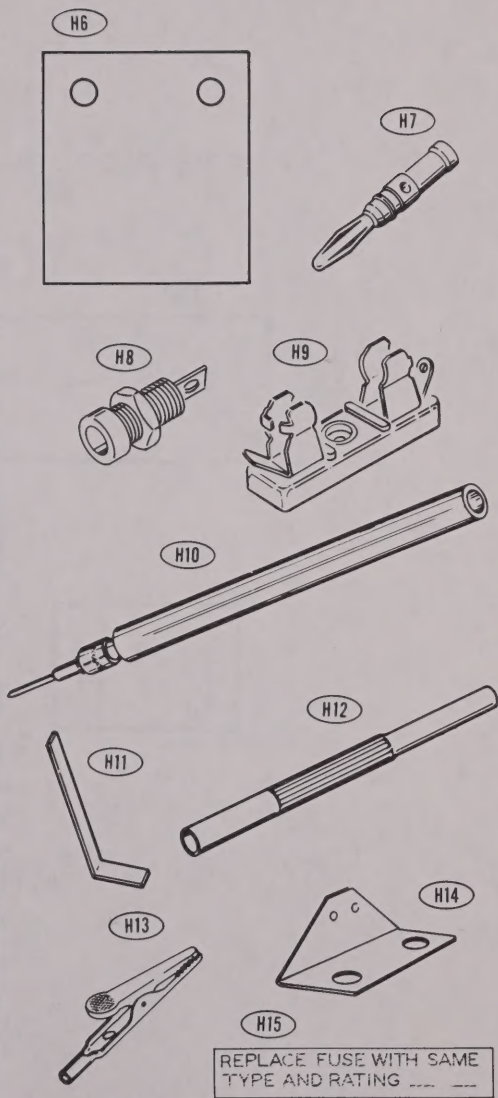
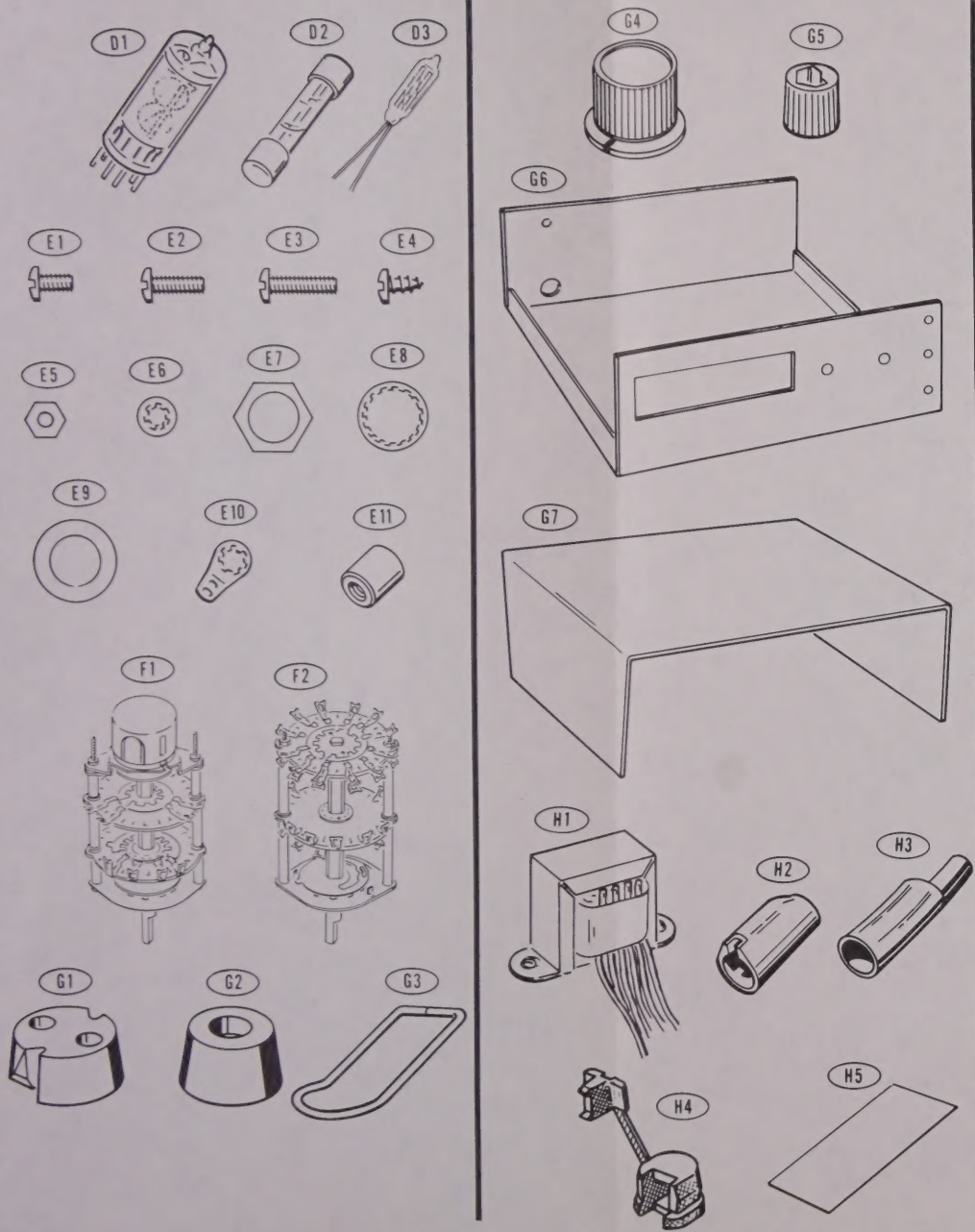
NOTE: If either the part number or the "Description" number is on an integrated circuit, you have the correct part. Do not be concerned about any other numbers. On integrated circuits, the description number may have additional letters or numbers other than those given in the list. Example: SN(7490)N or MC(7490)P.

(X)	C1 442-39	1	301A Eight-pin integrated circuit (IC)	2.35
(X)	C2 443-1	1	7400 Fourteen-pin integrated circuit (IC)	.70
(X)	C2 443-5	1	7473 Fourteen-pin integrated circuit (IC)	1.45
(X)	C2 443-7	2	7490 Fourteen-pin integrated circuit (IC)	2.95
(X)	C2 443-46	1	7402 Fourteen-pin integrated circuit (IC)	.85
(X)	C2 443-35	2	7441 Sixteen-pin integrated circuit (IC)	4.30

PARTS PICTORIAL



PARTS PICTORIAL (Continued)



KEY PART		PARTS	DESCRIPTION	PRICE	
No.	No.	Per Kit		Each	
TUBES-FUSES-LAMPS					
(X)	D1	411-284	2	Display tube	5.40
(X)	D2	421-2	1	3-ampere fuse (3 AG)	.15
(X)	D2	321-26	1	1/8-ampere slow- blow fuse (3AG)	.25
(X)	D3	412-63	2	Neon lamp	1.15
HARDWARE					
(X)	E1	250-56	11	6-32 x 1/4" screw	.05
(X)	E2	250-89	4	6-32 x 3/8" screw	.05
(X)	E3	250-162	6	6-32 x 1/2" screw	.05
(X)	E4	250-369	4	#6 x 1/4" sheet metal screw (black)	.05
(X)	E5	252-3	11	6-32 x 1/4" nut	.05
(X)	E6	254-1	15	#6 internal lockwasher	.05
(X)	E7	252-7	2	Control nut	.05
(X)	E8	254-5	2	Control lockwasher	.05
(X)	E9	253-10	2	Control flat washer	.05
(X)	E10	259-1	1	#6 solder lug	.05
(X)	E11	255-103	3	6-32 x 5/16" spacer	.10
(X)		255-713	2	6-32 x 5/16" wide spacer	.10
WIRE-TEST LEADS-LINE CORD					
(X)		344-21	1	30" Large red wire (stranded)	.05/ft
(X)		344-50	1	8-1/2" Black wire	.05/ft
(X)		344-51	1	8-1/2" Brown wire	.05/ft
(X)		344-52	1	18" Small red wire	.05/ft
(X)		344-54	1	22" Yellow wire	.05/ft
(X)		344-55	1	9" Green wire	.05/ft
(X)		344-56	1	15" Blue wire	.05/ft
(X)		344-59	1	36" White wire	.05/ft
(X)		341-1	1	48" Black test lead	.10/ft
(X)		341-2	1	48" Red test lead	.10/ft
(X)		89-23	1	Line cord	1.25

KEY PART		PARTS	DESCRIPTION	PRICE
No.	No.	Per Kit		Each
ROTARY SWITCHES				
(X) F1	63-698	1	6-position switch	5.50
(X) F2	63-699	1	5-position switch	6.90
CABINET AND CHASSIS PARTS				
(X) G1	261-35	2	Large plastic foot	.20
(X) G2	261-36	2	Small plastic foot	.15
(X) G3	266-846	2	Foot ring	.75
(X) G4	462-264	2	Knob	.75
(X) G5	455-50	2	Knob insert	.15
(X) G6	200-674-1	1	Chassis	5.85
(X) G7	90-1105-4	1	Cabinet	4.90
MISCELLANEOUS				
(X) H1	54-866	1	Power transformer	6.60
(X) H2	70-10	1	Black plastic sleeve	.25
(X) H2	70-11	1	Red plastic sleeve	.25
(X) H3	73-21	1	Alligator clip insulator	.15
(X) H4	75-71	1	Line cord strain relief	.15
(X) H5	75-109	1	Cardboard insulator	.25
(X) H6	75-716	1	Fish paper	.15
(X) H7	438-47	2	Input plug	.20
(X) H8	436-11	1	Red input jack	.20
(X) H8	436-22	1	Black input jack	.20
(X) H8	436-24	1	White input jack	.20
(X) H9	422-1	2	Fuseholder	.40
(X) H10	439-1	1	Test probe	.70
(X) H11	490-111	1	IC puller	.15
(X) H12	490-5	1	Nut starter	.15
(X) H13	260-1	1	Alligator clip	.10
(X) H14	204-1965	1	Switch mounting bracket	.55
(X)	331-7	1	Solder	.40
(X) H15	390-362	1	Fuse label	.15
(X)	391-34	1	Blue and white label	.15
(X)	597-1306	1	Parts Request Form	
(X)		1	Manual (See front cover for part number.)	

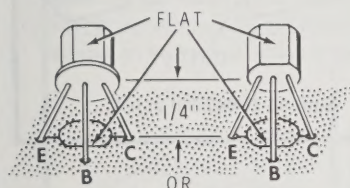
STEP-BY-STEP ASSEMBLY

CIRCUIT BOARD (Continued)

START

() Locate the partially assembled circuit board from kit ICN-1. Then position the circuit board as shown in the Pictorial and perform the following steps.

NOTE: Install each of the following transistors as shown. Solder each lead to the foil and cut off the excess lead lengths.



(X) 2N3638A transistor (#417-234) at Q6.

(X) MPSA20 transistor (#417-801) at Q2.

(X) MPS6520 transistor (#417-134) at Q1.

(X) MPSA20 transistor (#417-801) at Q5.

The steps performed in this Pictorial are in this area of the circuit board.

PART
NUMBER

CONTINUE

(X) MPSA42 transistor (#417-294) at Q13.

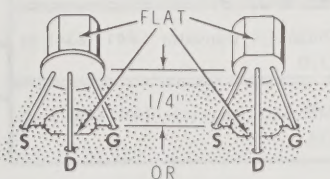
(X) MPSA42 transistor (#417-294) at Q14.

(X) MPS6520 transistor (#417-134) at Q15.

(X) 2N3638A transistor (#417-234) at Q4.

(X) MPSA20 transistor (#417-801) at Q3.

(X) 2N5458 transistor (#417-291) at Q7.

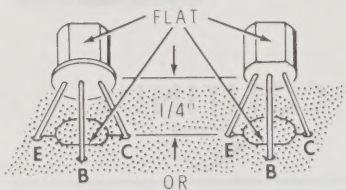


The steps performed in this Pictorial are in this area of the circuit board.

PART
NUMBER

START

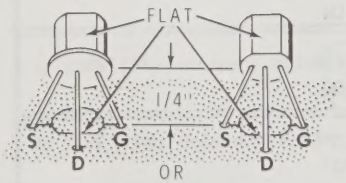
NOTE: Install each of the following transistors as shown. Solder each lead to the foil and cut off the excess lead lengths.



(X) MPS6520 transistor (#417-134) at Q16.

(X) MPS6520 transistor (#417-134) at Q12.

(X) 2N5458 transistor (#417-291) at Q8.

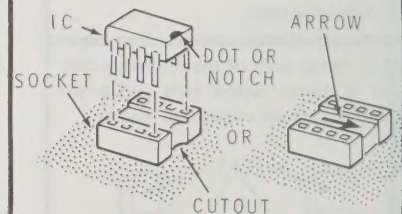


(X) 2N3638A transistor (#417-234) at Q10.

(X) MPSA20 transistor (#417-801) at Q9.

CONTINUE

NOTE: When you install the 8-pin IC in the following step, make sure the end marked with a dot or notch is positioned toward the cutout, or arrowhead, end of the socket.



(X) 8-pin IC (#442-39) at IC1.

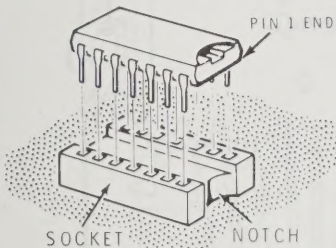
PICTORIAL 2-2

The steps performed in this Pictorial are in this area of the circuit board.

START

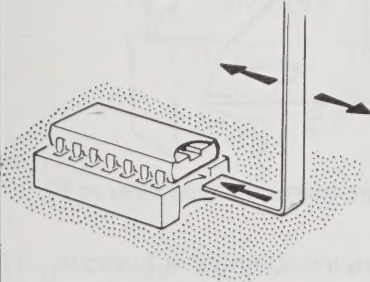
NOTE: Install the IC's (integrated circuits) in the following manner:

1. Refer to Detail 2-3A and locate the pin 1 end of the IC. Position this end of the IC over the identified end of the IC socket.
2. Before applying downward pressure, make sure each IC pin is centered in its proper socket aperture. Handle the IC's with care as their pins are very easily bent.
3. Carefully push the IC pins into the socket. Make sure all of the IC pins go into the socket. Seat the IC down as far as it will go.



(X) 7441 IC (#443-35) at IC3.

NOTE: An IC Lifter has been furnished to remove an IC from its socket if necessary.



Push the shorter end of the lifter in between the IC and the socket and rock the longer portion back and forth. Be very careful, as the IC pins are very easily bent.

(X) 7441 IC (#443-35) at IC4.

PART
NUMBER

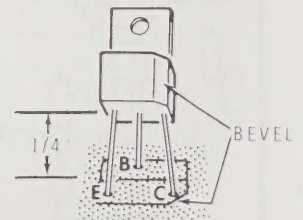
IDENTIFICATION
DRAWING

CONTINUE

(X) 7473 IC (#443-5) at IC5.

(X) 7400 IC (#443-1) at IC8. Make sure you position the marked end as shown.

NOTE: Bend the leads and install the following transistor as shown. Match the bevel on the transistor with the bevel outline on the circuit board. Solder the leads to the foil and cut off the excess lead lengths.



(X) D40C1 transistor (#417-272) at Q11.

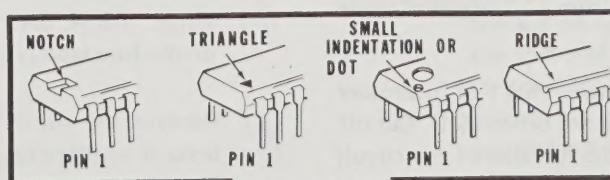
(X) 7490 IC (#443-7) at IC6.

(X) 7490 IC (#443-7) at IC7.

(X) 7402 IC (#443-46) at IC2.

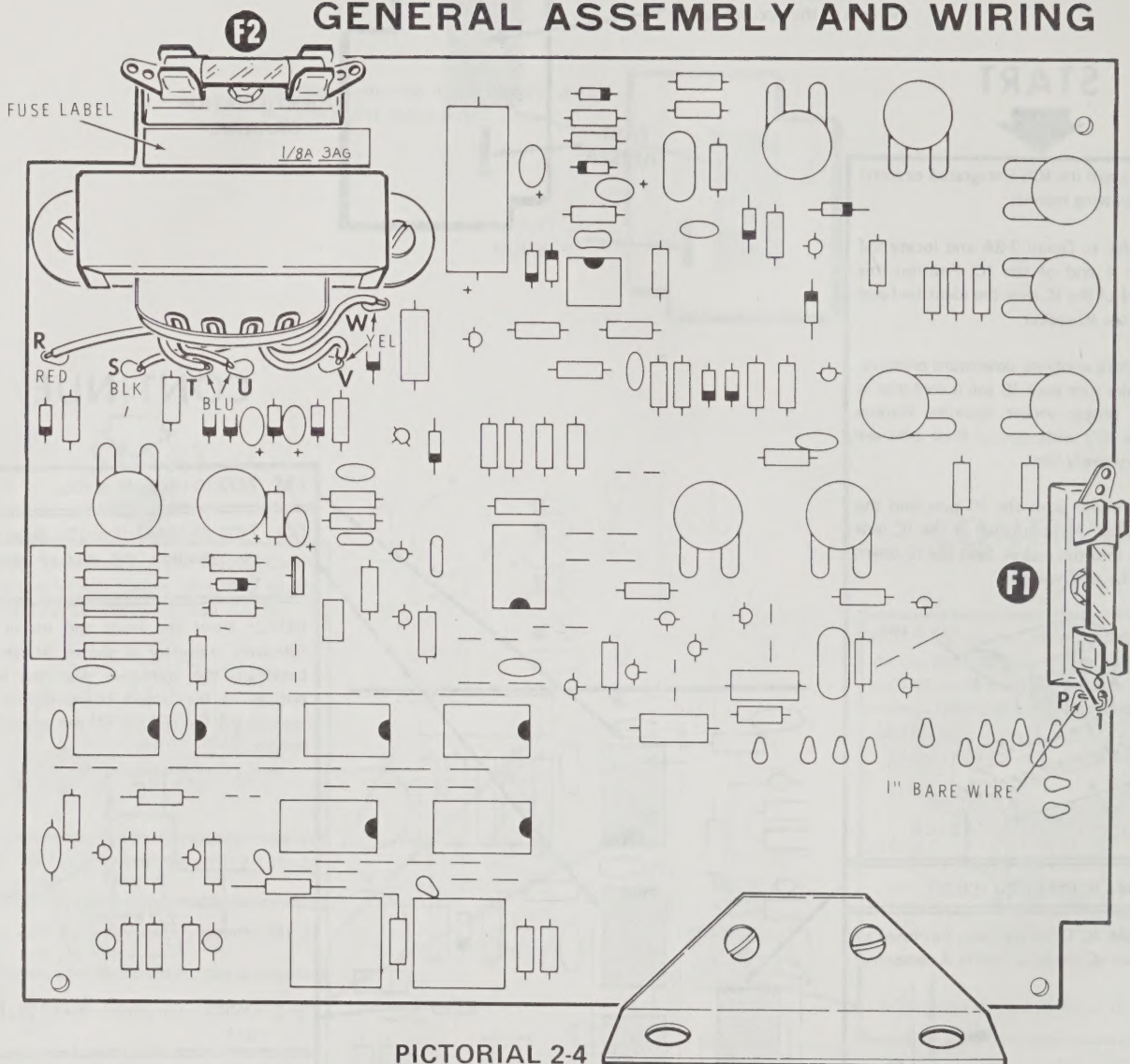
FINISH

PICTORIAL 2-3



Detail 2-3A

GENERAL ASSEMBLY AND WIRING



PICTORIAL 2-4

Refer to Pictorial 2-4 for the following steps.

NOTE: Use the nut starter to hold and start 6-32 nuts on screws.

- (X) Refer to Detail 2-4A and mount a fuseholder on the circuit board at F1. Use a 6-32 x 3/8" screw, a #6 lockwasher, and a 6-32 nut.

NOTE: In the following steps, (NS) means not to solder because other wires will be added later. "S—" with a number, such as (S-3), means to solder the connection. The number following the "S" tells how many wires are at the connection.

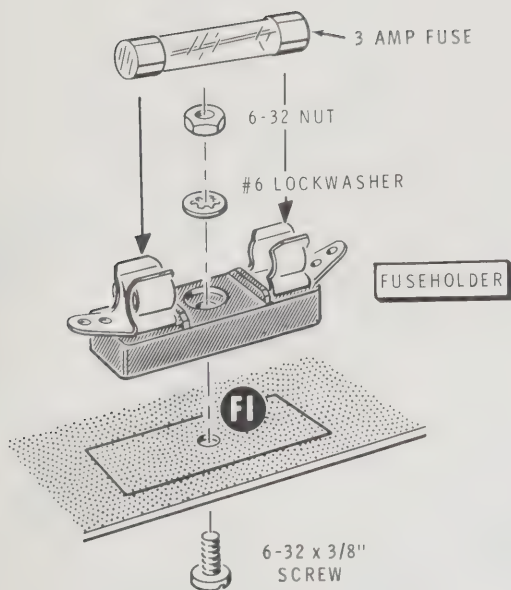
- (X) Remove all of the insulation from a 1" length of white wire.
- (X) Connect this 1" bare wire between lug 1 of fuseholder F1 (S-1) and hole P on the circuit board (S-1). Cut off any excess wire length on the foil side of the circuit board.

- (X) Install the 3-ampere fuse in the fuseholder at F1.

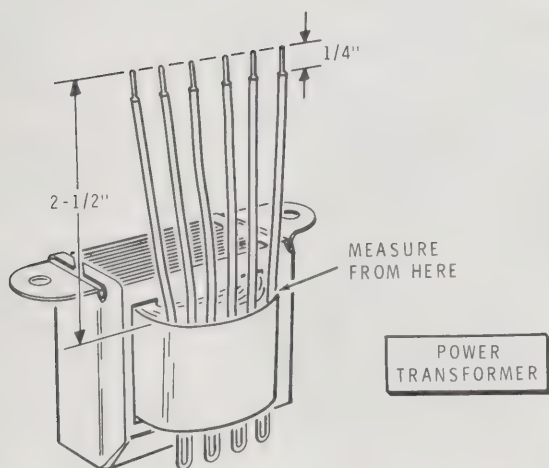
- (X) In a similar manner, mount the other fuseholder at F2. Use a 6-32 x 3/8" screw, a #6 lockwasher, and a 6-32 nut.

NOTE: In the following steps, disregard the "3AG 1/4 AMP" painted on the circuit board near fuseholder F2.

- (X) Install the 1/8-ampere slow-blow fuse in fuseholder F2.
- (X) Write "1/8 A, 3AG slow-blow" in the space provided on the fuse label.
- (X) Remove the paper backing from the fuse label and press it in place on the circuit board as shown in the Pictorial.



Detail 2-4A



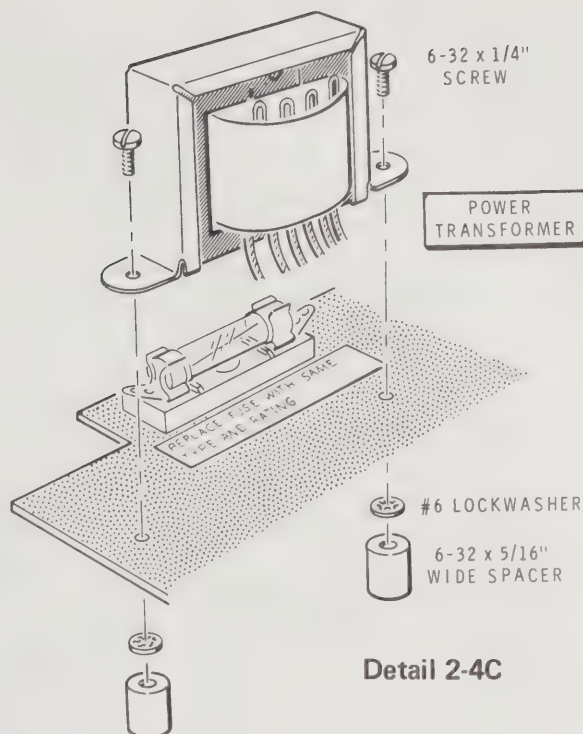
Detail 2-4B

(X) Locate the power transformer and cut all of the transformer wires to a length of 2-1/2" as shown in Detail 2-4B. Then remove 1/4" of insulation from the end of each wire.

(X) Mount the transformer on the circuit board as shown in Detail 2-4C. Use two 6-32 x 1/4" screws, two #6 lockwashers and two 6-32 x 5/16" wide spacers.

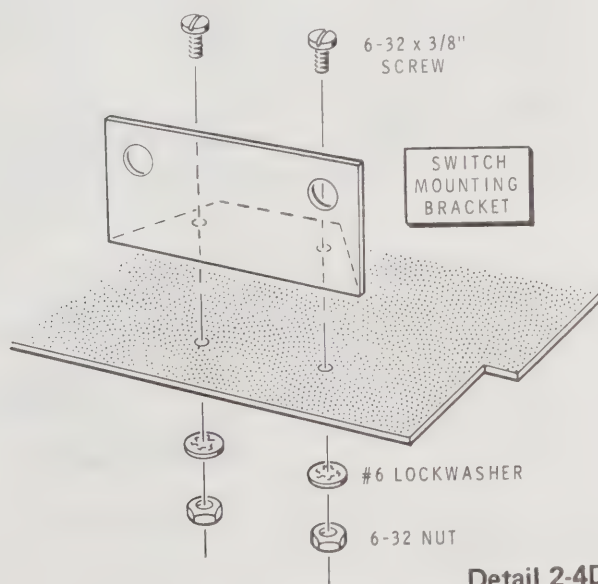
Connect the transformer wires to the circuit board as follows:

- (X) Red wire to hole R (S-1).
- (X) Black wire to hole S (S-1).
- (X) Either blue wire to hole T (S-1).



Detail 2-4C

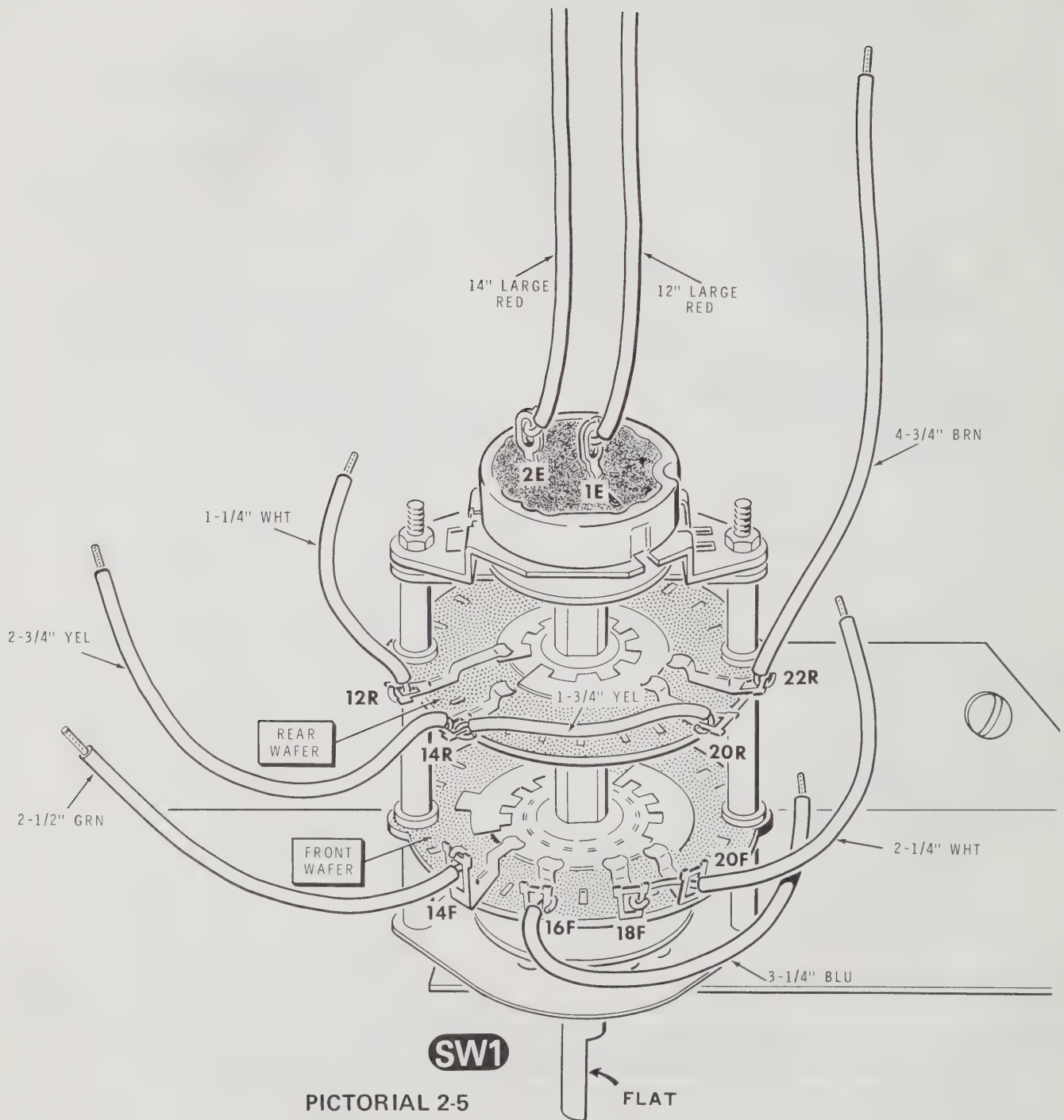
- (X) Other blue wire to hole U (S-1).
- (X) Either yellow wire to hole V (S-1).
- (X) Other yellow wire to hole W (S-1).



Detail 2-4D

- (X) Refer to Detail 2-4D and mount the switch mounting bracket on the circuit board at the location shown in the Pictorial. Use two 6-32 x 3/8" screws, two #6 lockwashers, and two 6-32 nuts. Make sure the bracket is lined up with the edge of the circuit board before you tighten the screws.





SWITCH WIRING

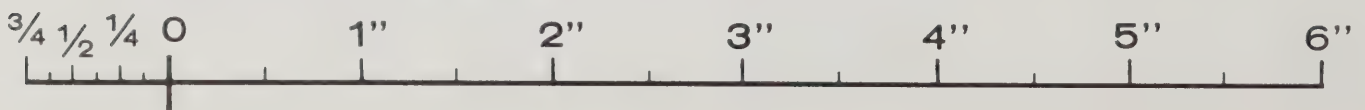
Refer to Pictorial 2-5 for the following steps.

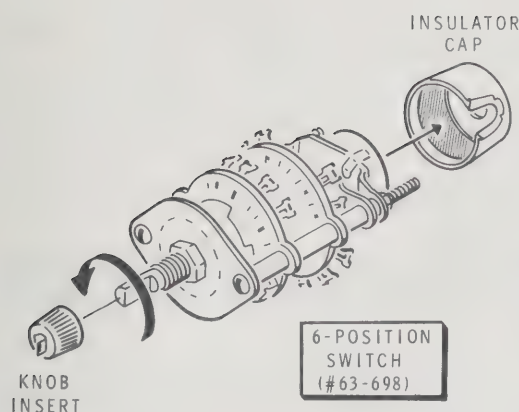
(X) Locate the 6-position switch (#63-698).

(X) Refer to Detail 2-5A and remove the insulator cap from the rear of the switch. Then place a knob insert on the switch shaft.

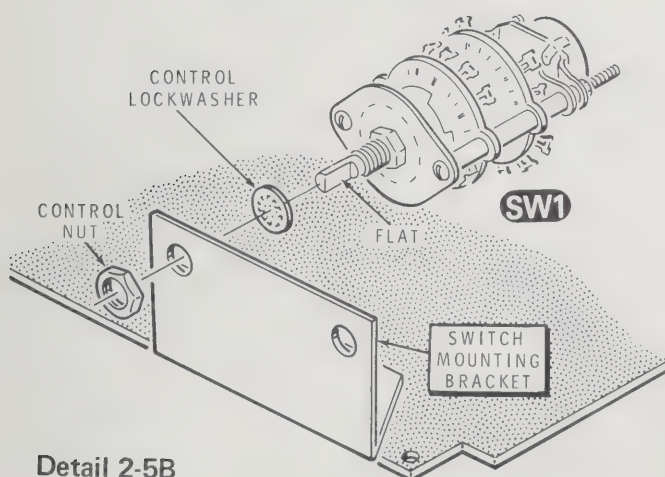
(X) Position the switch shaft toward you and rotate the shaft fully counterclockwise as shown in the Detail. Leave the shaft in this position during the entire assembly of the kit.

NOTE: When you mount the switch in the following step, make sure the flat on its shaft is positioned as shown in Pictorial 2-5.





Detail 2-5A



Detail 2-5B

- (X) Remove the knob insert from the switch shaft. Then mount the switch to the switch mounting bracket at SW1 on the circuit board. Use a control lockwasher and a control nut as shown in Detail 2-5B. Tighten the control nut only finger tight. The switch will be rotated in a later step to permit wiring the other side.

NOTES:

1. The lugs of switch SW1 are numbered in a clockwise direction as viewed from the front. Each possible lug location is numbered even though every hole does not have a lug. The two wafers are designated as F (front) and R (rear) as viewed from the front of the switch.
2. When wiring this kit, you will be instructed to prepare lengths of wire ahead of time, as in the next step. To prepare a wire, cut it to the length specified in the step and remove 1/4" of insulation from each end. The wires are listed in the order in which they will be used. Use only the small wire unless large wire is specifically called for in the step.

- (X) Prepare the following lengths of small wire:

1-1/4" white	1-3/4" yellow
2-3/4" yellow	4-3/4" brown

NOTE: In some of the following steps you may be instructed to connect only one end of a wire. Do not be concerned about any unconnected wire ends. They will be connected in later steps.

Connect the wires to the switch lugs as follows:

- (X) 1-1/4" white to lug 12R (S-1). Position the free end of this wire around the switch as shown in the Pictorial.
- (X) 2-3/4" yellow to lug 14R (NS).
- (X) 1-3/4" yellow between lug 14R (S-2) and lug 20R (S-1).
- (X) 4-3/4" brown to lug 22R (S-1).
- (X) Prepare the following lengths of small wire:

2-1/2" green
3-1/4" blue
2-1/4" white

Connect the wires to the switch lugs as follows:

- (X) 2-1/2" green to lug 14F (S-1).
- (X) 3-1/4" blue to lug 16F (S-1). Position the free end of this wire around the switch as shown in the Pictorial.

NOTE: Where a wire end passes through a lug and then goes elsewhere, as in the following step, it will be treated as two wires in the soldering instructions (S-2), one entering and one leaving the lug.

- (X) Remove an additional 3/8" of insulation from one end of the 2-1/4" white wire. Then route this 5/8" stripped end through lug 20F (S-2) to lug 18F (S-1).

NOTE: Make sure you do not use the red test lead in the following step. The red test lead is longer and more flexible than the large red wire.

- (X) Prepare the following lengths of large wire:

14" large red
12" large red

- (X) Connect the large red wires to the lugs on the end of switch SW1 as follows:

- (X) 14" large red to lug 2E (S-1).
- (X) 12" large red to lug 1E (S-1).

Refer to Pictorial 2-6 for the following steps.

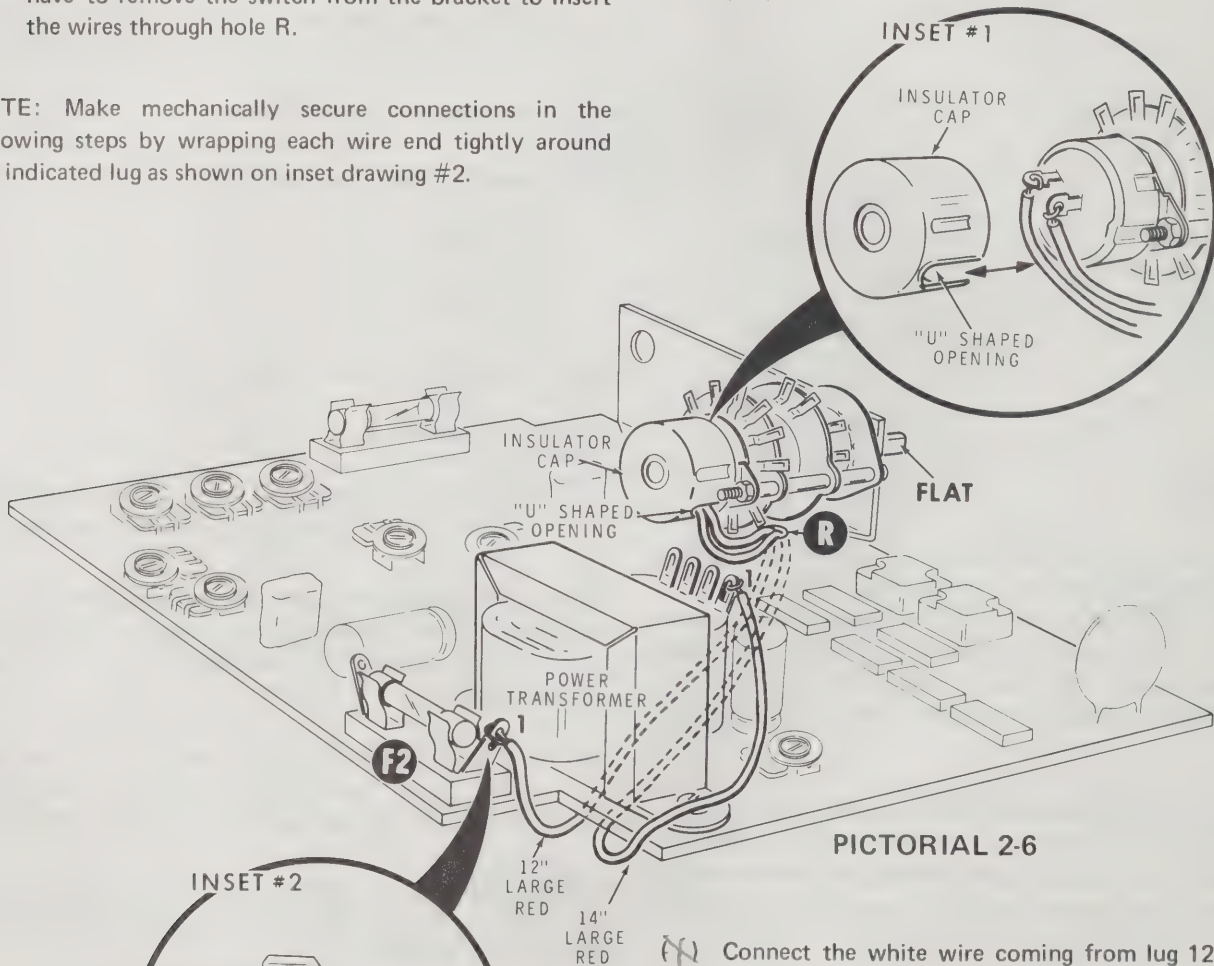
- (1) Loosen the control nut and turn the switch one-half turn so the other side is up.
- (2) Refer to inset drawing #1 and replace the insulator cap on the switch. Route the red stranded wires through the "U" shaped opening in the cap as shown.
- (3) Insert both red stranded wires down through hole R in the circuit board and route them underneath as indicated by the dashed lines in the Pictorial. You may have to remove the switch from the bracket to insert the wires through hole R.

NOTE: Make mechanically secure connections in the following steps by wrapping each wire end tightly around the indicated lug as shown on inset drawing #2.

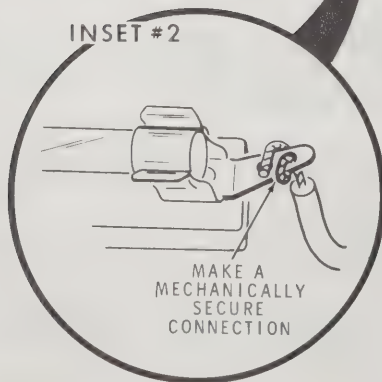
- (X) Connect the 14" large red wire to lug 1 of the power transformer (NS).
- (X) Connect the 12" large red wire to lug 1 of fuse F2 (S-1).

Refer to Pictorial 2-7 for the following steps.

- (X) Retighten the control nut finger tight on the switch shaft. Make sure the flat on the shaft is positioned as shown.
- (X) Connect the blue wire coming from lug 16F to lug 5R (NS).



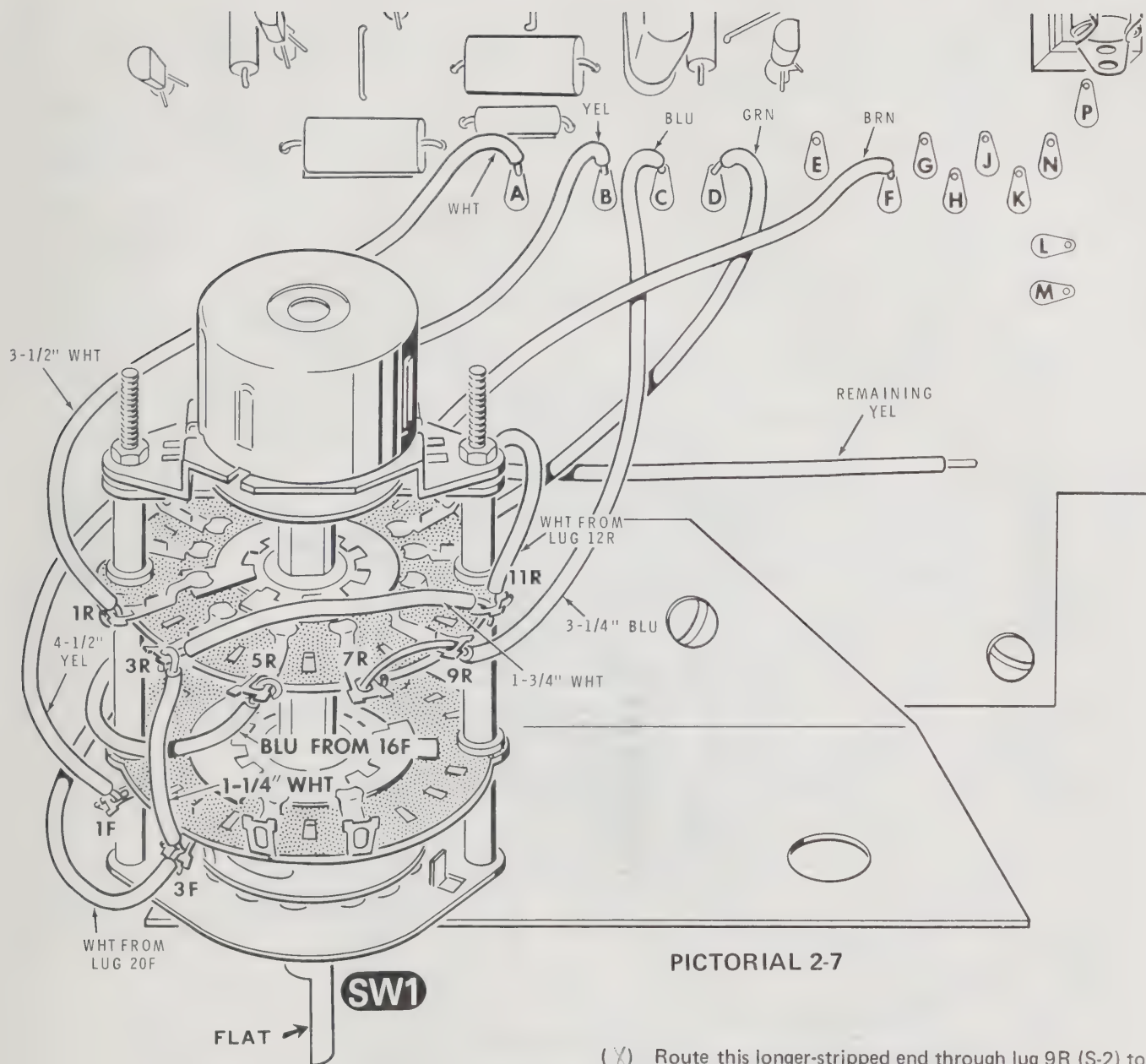
PICTORIAL 2-6



- (X) Connect the white wire coming from lug 12R to lug 11R (NS).
- (X) Connect the white wire coming from lug 20F to lug 3F (NS). Position this wire as shown in the Pictorial.
- (X) Prepare the following lengths of small wire:

3-1/2" white	1-3/4" white
4-1/2" yellow	3-1/4" blue
1-1/4" white	





PICTORIAL 2-7

(X) Route this longer-stripped end through lug 9R (S-2) to lug 7R (S-1).

Connect the wires on switch SW1 to the circuit board as follows:

Connect the wires to the switch lugs as follows:

(X) 3-1/2" white to lug 1R (S-1).

(X) 4-1/2" yellow to lug 1F (S-1).

(X) 1-1/4" white between lug 3F (S-2) and lug 3R (NS).

(X) 1-3/4" white between lug 3R (S-2) and lug 11R (S-2).

(X) Remove an additional 3/8" of insulation from one end of the 3-1/4" blue wire.

(X) White to hole A (S-1).

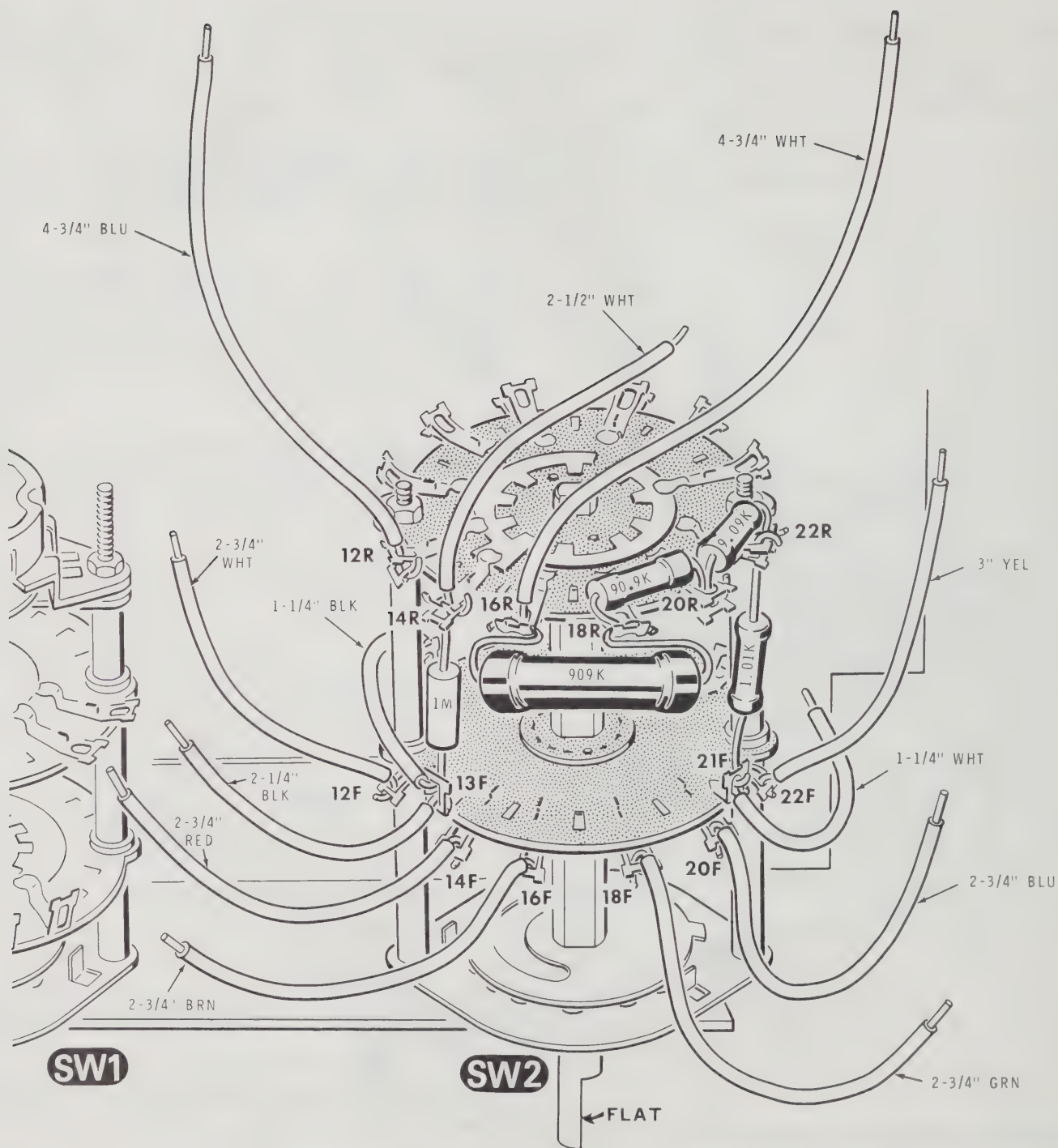
(X) 4-1/2" yellow coming from lug 1F to hole B (S-1).

(X) Blue to hole C (S-1).

(X) Green to hole D (S-1).

(X) Brown to hole F (S-1).

The remaining yellow wire will be connected later.



PICTORIAL 2-8

Refer to Pictorial 2-8 for the following steps.

(1) Locate the 5-position switch (#63-699) and place a knob insert on the switch shaft.

(2) Position the switch shaft toward you and rotate it fully counterclockwise. Leave the shaft in this position during the assembly of this kit.

(3) Remove the knob insert. Then mount the 5-position switch to the switch mounting bracket at SW2. Use a

control lockwasher and a control nut. Make sure the flat on the switch shaft is positioned as shown.

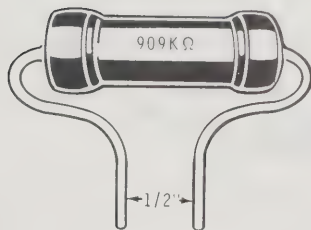
NOTE: The rear wafer of this switch has double lugs. When you make connections to these lugs, connect the wires or resistor leads to both lugs as shown in the Pictorial.

- (X) Prepare a 4-3/4" blue wire. Then connect one end to lug 12R (S-1).
- (X) Connect a 1 M Ω , 5% (brown-black-green-gold) resistor between lug 14R (NS) and lug 13F (NS).
- (X) Prepare a 2-1/2" white wire and connect one end to lug 14R (S-2). Position the other end of this wire down behind the switch as shown in the Pictorial.

NOTE: When you connect precision resistors to the switch lugs, as in the following steps, make sure you identify each resistor correctly. It might be easy, for example, to mistake a 909 k Ω resistor for a 90.9 k Ω resistor.



Detail 2-8A



Detail 2-8B

- (X) Refer to Detail 2-8A and cut the leads of a 909 k Ω , .5% precision resistor to a length of 1" as shown. Then shape the leads as shown in Detail 2-8B.
- (X) Connect this 909 k Ω precision resistor between lug 16R (NS) and lug 18R (NS).
- (X) Prepare a 4-3/4" white wire. Then connect one end to lug 16R (S-2).

Connect precision resistors to the switch lugs as follows:

- (X) 90.9 k Ω , between lug 18R (S-2) and lug 20R (NS).

- (X) 1.01 k Ω , from lug 22R (NS) to lug 21F (NS).

- (X) 9.09 k Ω , between lug 20R (S-2) and lug 22R (S-2).

- (X) Prepare the following lengths of small wire:

2-3/4" white
1-1/4" black
2-1/4" black
2-3/4" red
2-3/4" brown

Connect the wires to the switch lugs as follows:

- (X) 2-3/4" white to lug 12F (S-1).

- (X) 1-1/4" black to lug 13F (NS). Position this wire around the outside of the switch as shown in the Pictorial.

- (X) 2-1/4" black to lug 13F (S-3).

- (X) 2-3/4" red to lug 14F (S-1).

- (X) 2-3/4" brown to lug 16F (S-1).

- (X) Prepare the following lengths of small wire:

2-3/4" green
2-3/4" blue
1-1/4" white
3" yellow

Connect the wires to the switch lugs as follows:

- (X) 2-3/4" green to lug 18F (S-1).

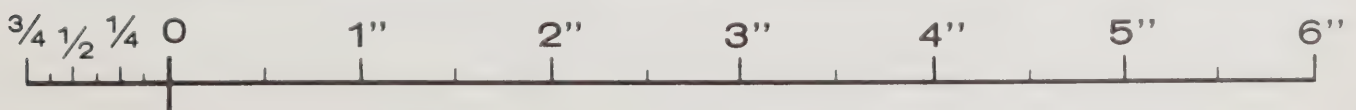
- (X) 2-3/4" blue to lug 20F (S-1).

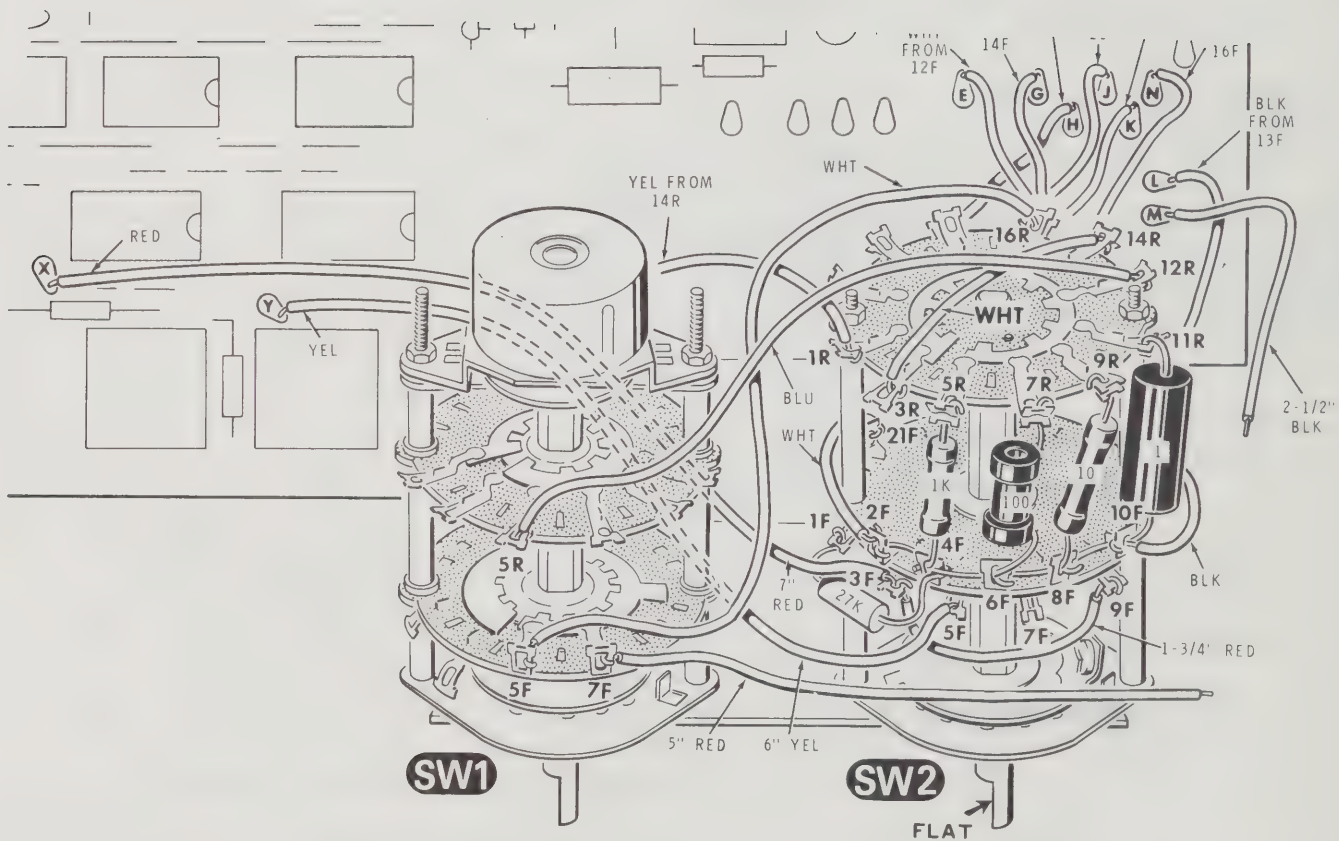
- (X) 1-1/4" white to lug 21F (S-2). Position this wire around the outside of the switch as shown in the Pictorial.

- (X) 3" yellow to lug 22F (S-1).

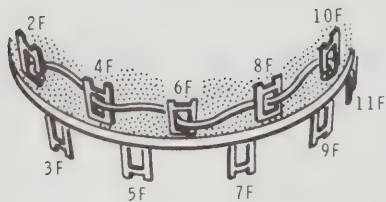
- (X) Cut off all excess resistor leads and make sure there are no protruding leads or wires that could cause a short circuit between switch lugs.

- (X) Position all wires as shown in the Pictorial.

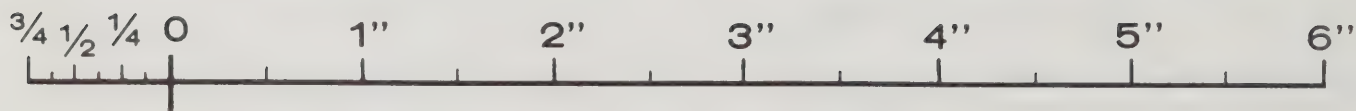




PICTORIAL 2-9



Detail 2-9A



Refer to Pictorial 2-9 for the following steps.

- (X) Loosen the control nut and turn the switch so the flat on its shaft is positioned as shown in Pictorial 2-9. Then tighten the control nut.

Connect the wires to the lugs of switch SW2 as follows:

- (X) Remove all of the insulation from a 2-1/4" white wire.
- (X) Refer to Detail 2-9A and connect the 2-1/4" bare wire from lug 2F, through lugs 4F, 6F, and 8F and to lug 10F. Do not solder any of the connections at this time.
- (X) White wire coming from lug 14R to lug 3R (S-1).
- (X) White wire coming from lug 21F to lug 2F (S-2).
- (X) 1-1/4" black wire coming from lug 13F to lug 10F (NS).

Connect precision resistors to the switch lugs as follows:

- (X) 1000 Ω (1 k), .5% between lugs 5R (S-1) and 4F (NS).
- (X) 100 Ω , .5% between lugs 7R (S-1) and 6F (S-3).
- (X) 10.0 Ω , .5% between lugs 9R (S-1) and 8F (S-3).
- (X) 1 Ω , 1% between lugs 11R (S-1) and 10F (S-3).

NOTE: Lugs 7F and 11F on this switch will not be used.

- (X) Connect one lead of a 27 k Ω , 5% (red-violet-orange-gold) resistor to lug 1F (S-1). Wrap the other lead around lug 4F as shown in the Pictorial (S-4).
- (X) Cut off all excess resistor leads. Make sure there are no protruding leads that could cause a short circuit between switch lugs.
- (X) Prepare a 1-3/4" small red wire.
- (X) Connect this 1-3/4" red wire from lug 3F (NS) to lug 9F (S-1).
- (X) Prepare a 7" small red wire and connect one end to lug 3F on switch SW2 (S-2).

- (X) Route this red wire under switch SW1 as shown in the Pictorial and connect the other end to hole X on the circuit board (S-1).

- (X) Prepare a 6" small yellow wire and connect one end to lug 5F on switch SW2 (S-1).

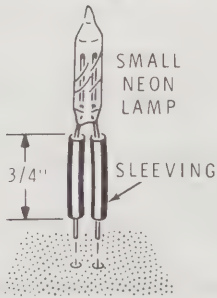
- (X) Route the other end of the yellow wire under switch SW1 and connect it to hole Y on the circuit board (S-1).

Connect the wires coming from switch SW2 to the circuit board as follows:

- (X) 2-3/4" white coming from lug 12F to hole E (S-1).
- (X) 2-3/4" red coming from lug 14F to hole G (S-1).
- (X) 3" yellow coming from lug 22F to hole H (S-1).
- (X) 2-3/4" blue coming from lug 20F to hole J (S-1).
- (X) 2-3/4" green coming from lug 18F to hole K (S-1).
- (X) 2-3/4" brown coming from lug 16F to hole N (S-1).
- (X) 2-1/4" black coming from lug 13F to hole L (S-1).
- (X) Prepare a 2-1/2" small black wire. Then connect one end to hole M on the circuit board. The other end will be connected later.
- (X) Connect the 2-3/4" yellow wire coming from lug 14R on switch SW1 to lug 1R on switch SW2 (S-1).
- (X) Connect the 4-3/4" blue wire coming from lug 12R on switch SW2 to lug 5R on switch SW1 (S-2).
- (X) Connect the 4-3/4" white wire coming from lug 16R on switch SW2 to lug 5F on switch SW1 (S-1).
- (X) Prepare a 5" small red wire and connect one end to lug 7F on switch SW1 (S-1). The other end will be connected later.

CONTINUE

START

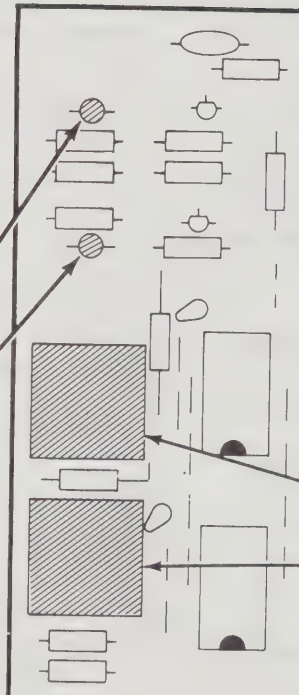


SMALL NEON LAMP

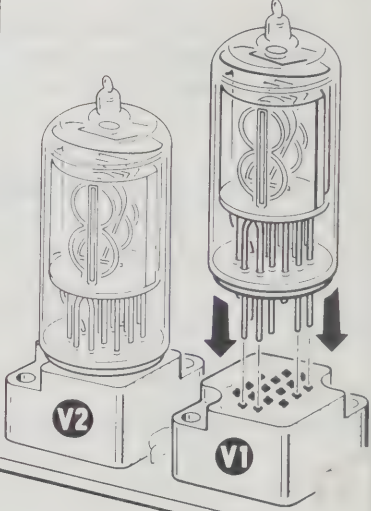
3/4"

SLEEVING

- () Place a 3/4" length of sleeving over each lead of both neon lamps.
- () Install a neon lamp at DS201.
- () Install the other neon lamp at DS202.
- () Solder the leads to the foil and cut off the excess lead lengths.



NOTE: When you install the display tubes in the following steps, make sure all of the tube pins are straight. Then position the tubes so the display numbers face the outside edge of the circuit board and push the tubes gently down into the sockets.



V2

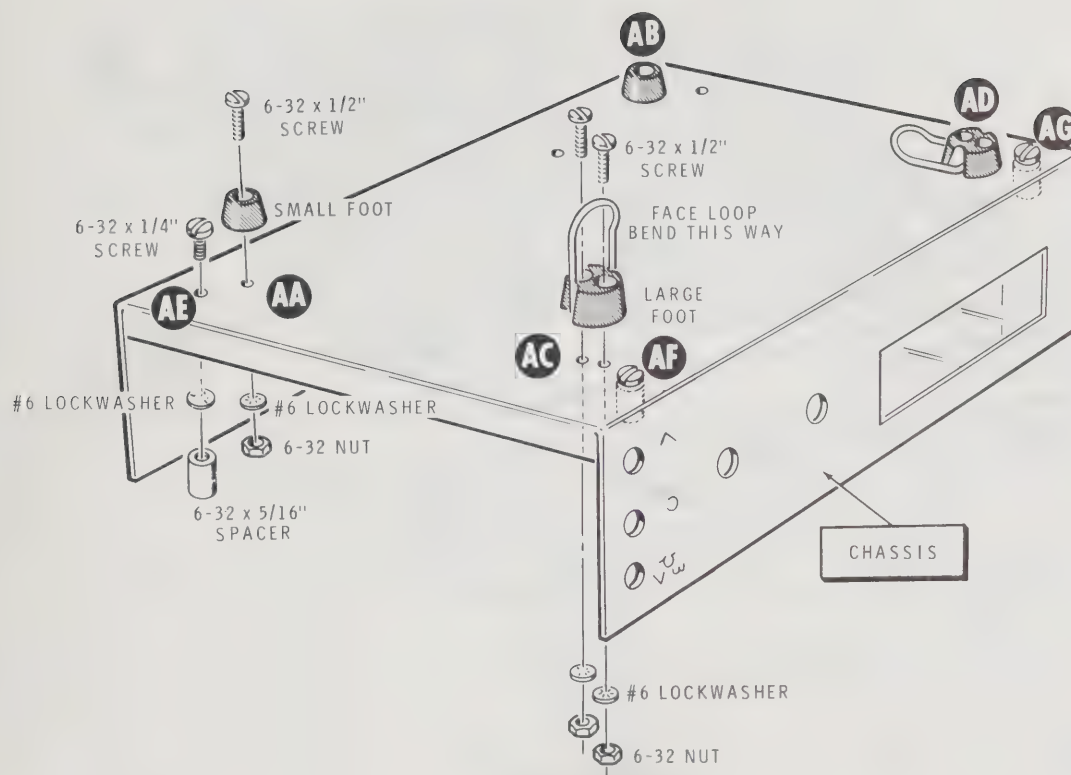
V1

- () Display tube at V2.
- () Display tube at V1.

Set the circuit board aside temporarily.

PICTORIAL 2-10



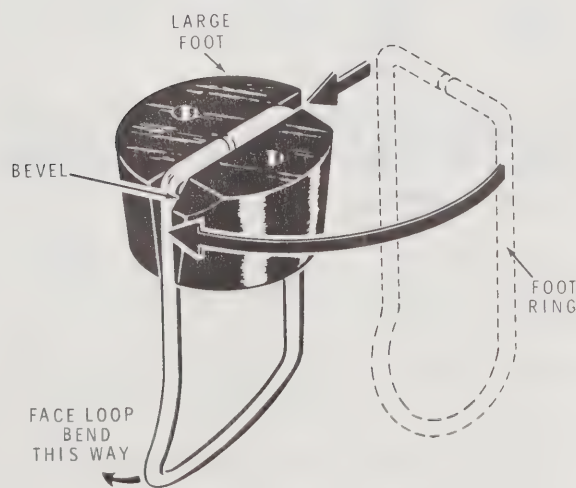


PICTORIAL 2-11

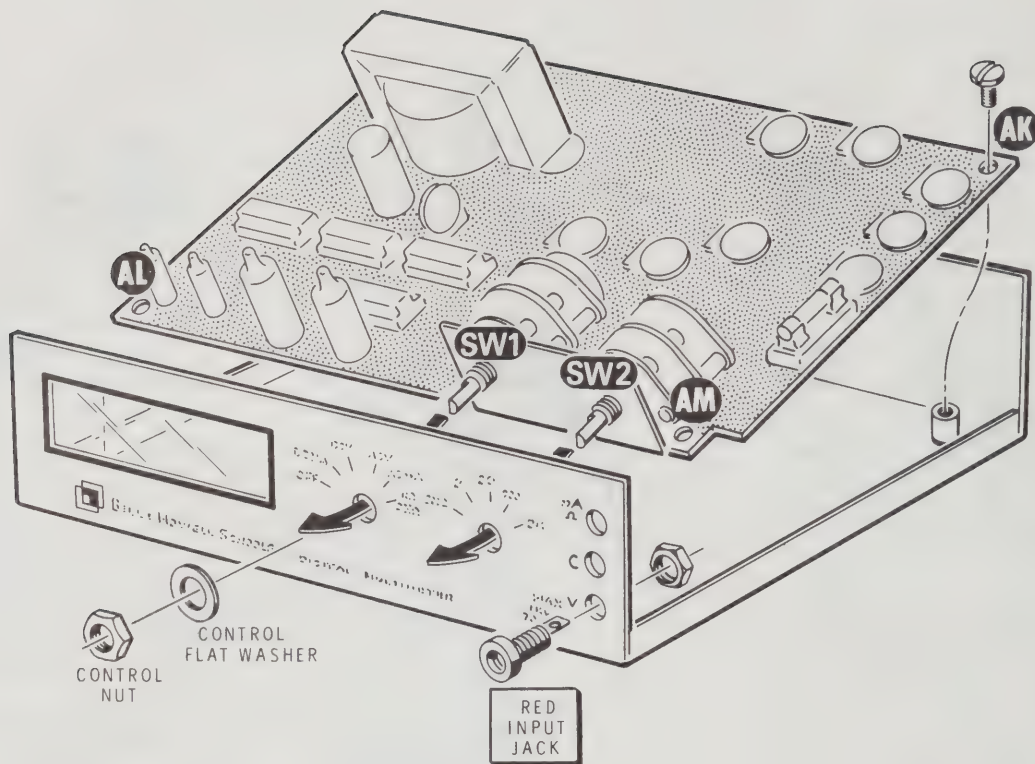
CHASSIS ASSEMBLY AND WIRING

Refer to Pictorial 2-11 for the following steps.

- (X) Position the chassis as shown in the Pictorial.
- (X) Mount 6-32 x 5/16" spacers at holes AE, AF, and AG with 6-32 x 1/4" screws and #6 lockwashers.
- (X) Mount small feet at holes AA and AB. Use two 6-32 x 1/2" screws, two #6 lockwashers and two 6-32 nuts.
- (X) Refer to Detail 2-11A and install a foot ring on each of the two large feet.
- (X) Mount large feet at holes AC and AD. Use four 6-32 x 1/2" screws, four #6 lockwashers and four 6-32 nuts. Make sure both feet are positioned as shown in the Pictorial with the beveled edge toward the rear of the chassis. Then lay the foot ring flat and make sure it remains straight while you tighten the screws.



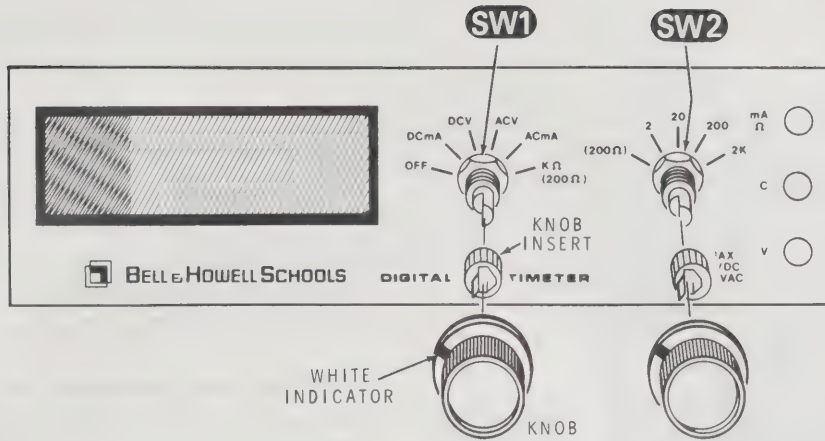
Detail 2-11A



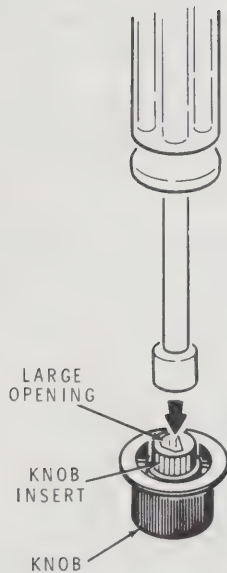
PICTORIAL 2-12

Refer to Pictorial 2-12 for the following steps.

- (X) Remove the two control nuts from switches SW1 and SW2.
- (X) Position the shafts of the switches through the holes at the front of the chassis and set the circuit board down inside the chassis.
- (Y) Mount the two switches to the chassis with control flat washers and control nuts. Tighten the control nuts securely.
- (X) Place a knob insert on the shaft of switch SW1. Make sure the shaft is turned fully counterclockwise.
- (X) Refer to Detail 2-12A and push a knob on the knob insert with the white indicator positioned to the "OFF" position. Press the knob part way onto the insert.



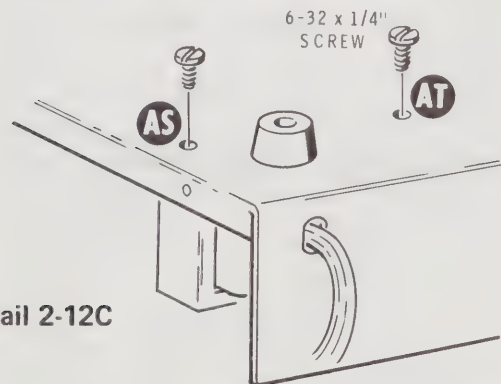
Detail 2-12A



Detail 2-12B

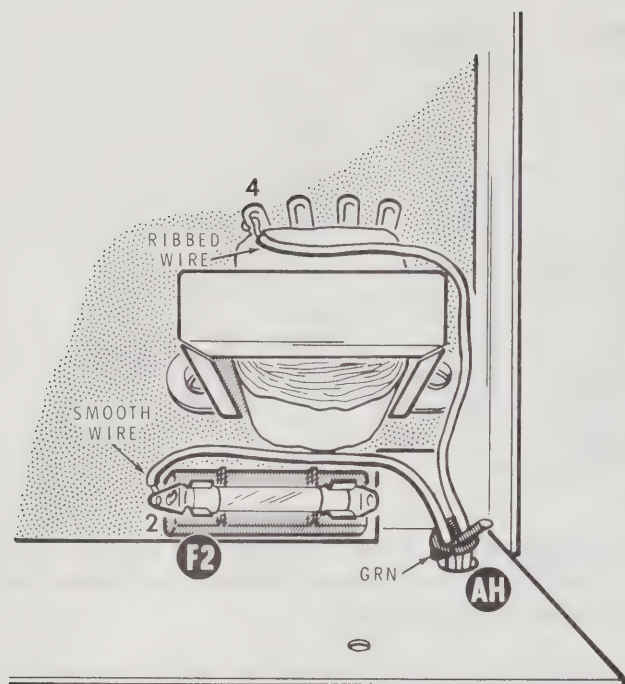
- (X) Carefully remove the knob and insert together. Then press the insert fully into the knob with a tool as shown in Detail 2-12B.
- (X) Replace the knob on the shaft of switch SW1.
- (X) Place a knob insert on the shaft of switch SW2. Make sure the shaft is turned fully counterclockwise.
- (X) Place a knob on the insert with the white indicator positioned toward the "200 Ω" position.
- (X) Press the knob part way onto the insert.

- (X) As before, remove the knob and insert together. Then press the insert fully into the knob and replace the knob on the switch shaft.
- (X) Fasten the circuit board to the chassis with 6-32 x 1/4" screws at holes AK, AL, and AM.
- (X) Refer to Detail 2-12C and install 6-32 x 1/4" screws in the chassis bottom at AS and AT.

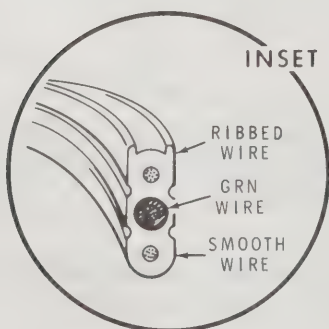
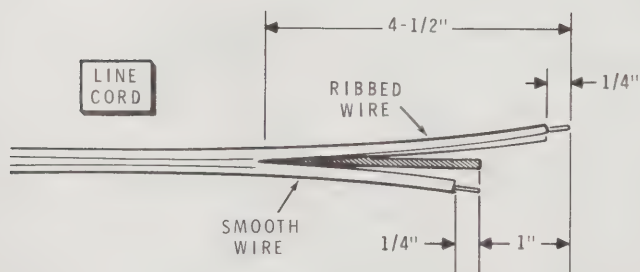


Detail 2-12C

- (X) As before, remove the knob and insert together. Then press the insert fully into the knob and replace the knob on the switch shaft.
 - (X) Fasten the circuit board to the chassis with 6-32 x 1/4" screws at holes AK, AL, and AM.
- NOTE: In the following steps, mount the input jacks on the chassis with their attached nuts.
- (X) Red input jack at the hole marked "V."
 - (X) Black input jack at the hole marked "C."
 - (X) White input jack at the hole marked "mA Ω."



PICTORIAL 2-13



Detail 2-13A

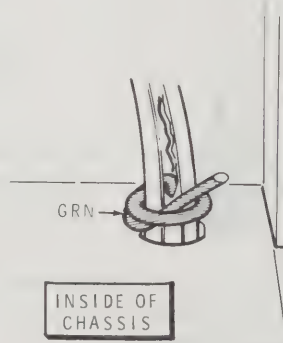
Refer to Pictorial 2-13 for the following steps.

Refer to Detail 2-13A and prepare the line cord as follows:

- (X) Separate the three wires for a length of 4-1/2". Identify the smooth wire from the inset drawing; then cut 1" off both the smooth wire and the green wire.
- () Remove 1/4" of insulation from the end of the smooth wire. Do not remove any insulation from the end of the green wire at this time.
- (X) Twist the small wire strands together on the ribbed wire and on the smooth wire. Then melt a small amount of solder on the ends to hold the strands together.
- (X) Insert the line-cord wires through hole AH at the rear of the chassis as shown in the Pictorial.

NOTE: Be sure to make the connections in the following steps mechanically secure by wrapping each wire end tightly around the indicated lug.

- (X) Connect the smooth wire to lug 2 of fuseholder F2 (S-1).



Detail 2-13B

- (X) Refer to Detail 2-13B and temporarily tie the green wire around the line cord near hole AH in the chassis. This will prevent the green wire from accidentally causing a short circuit when you are performing tests and adjustments.
- (X) Connect the ribbed line cord wire to lug 4 of the transformer (NS).



ALTERNATE POWER TRANSFORMER WIRING

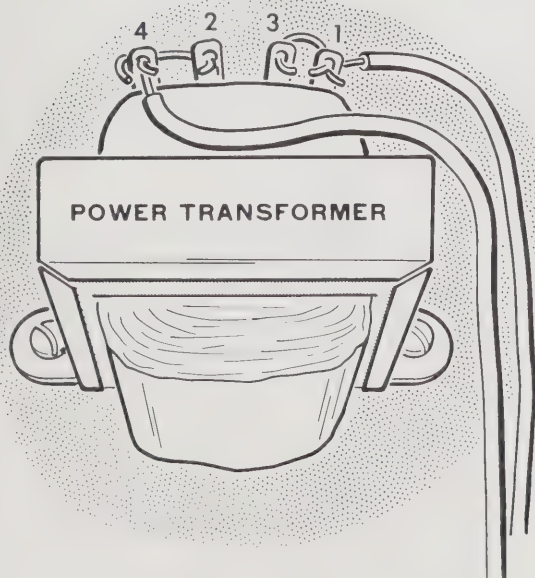
NOTE: The following steps give two different sets of wiring instructions. One set of instructions is for 120 VAC line voltage and the other is for 240 VAC line voltage. In the United States, 120 VAC is most often used, while in many other countries 240 VAC is more common. Use only the instructions that agree with the line voltage in your area.

For 120 VAC Only

Refer to Detail 2-13C for the following steps. Make each connect mechanically secure before soldering.

- (X) Remove all of the insulation from a 1" length of white wire. Connect this bare wire between lugs 1 (S-2) and 3 (S-1) of the power transformer.
- (X) Remove all of the insulation from a 1" length of white wire. Connect this bare wire between lugs 2 (S-1) and 4 (S-2) of the power transformer.

120 VOLT WIRING



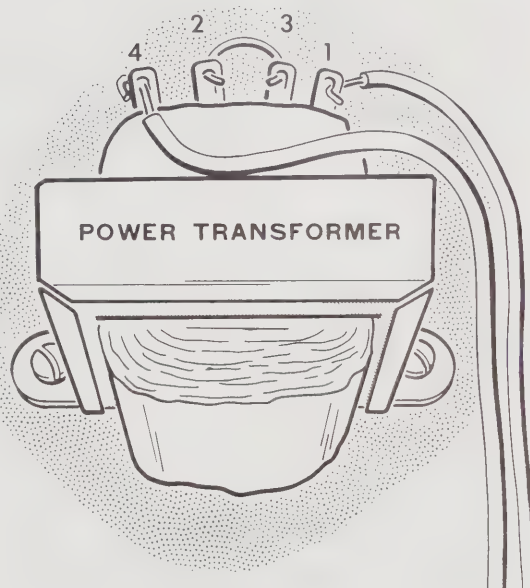
Detail 2-13C

For 240 VAC Only

Refer to Detail 2-13D for the following steps. Make each connection mechanically secure before soldering.

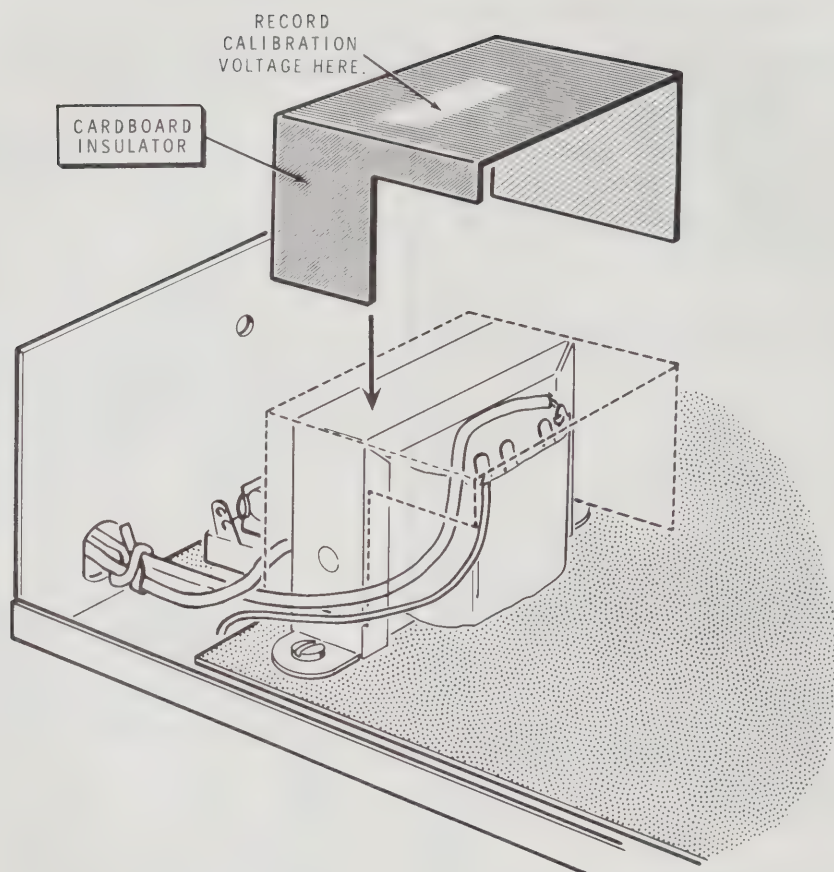
- () Solder the connection at lug 4 of the power transformer (S-1).
- () Solder the connection at lug 1 of the power transformer (S-1).
- () Remove all of the insulation from a 1" length of white wire. Connect this bare wire between lugs 2 (S-1) and 3 (S-1) of the power transformer.

240 VOLT WIRING



Detail 2-13D

CAUTION: A 1/16-ampere slow-blow fuse (not supplied with this kit) must be used in fuseholder F2 when the Multimeter is wired for 240 VAC operation.

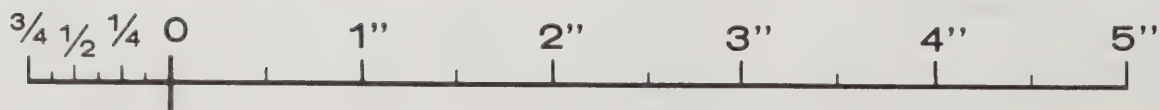


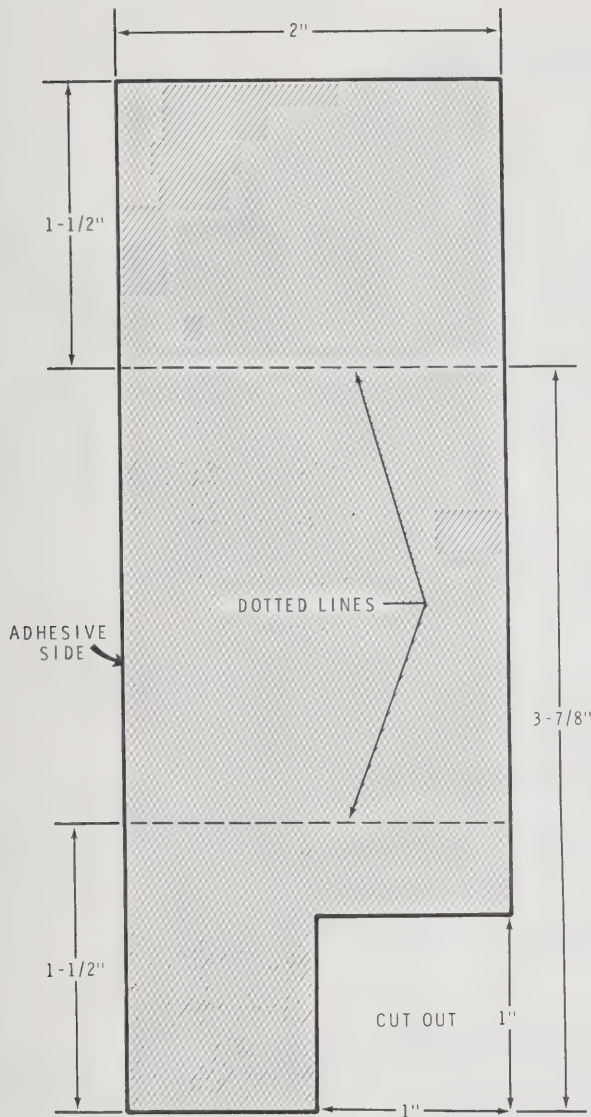
PICTORIAL 2-14

Refer to Pictorial 2-14 for the following steps.

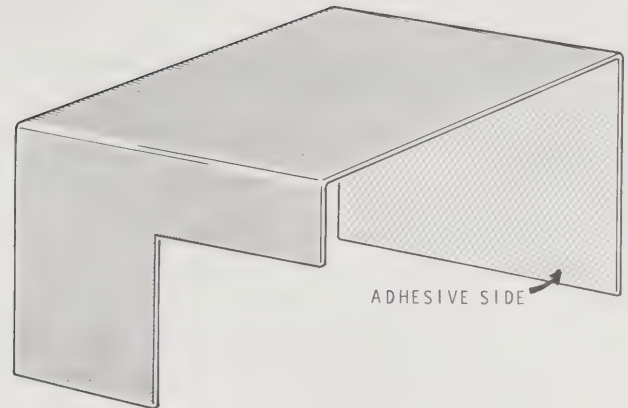
Refer to Detail 2-14A and prepare the cardboard insulator as follows:

1. (X) Cut the insulator to a width of 2". Then lay the insulator on your work surface with the adhesive side down.
2. (X) Cut out a 1" square from the lower right-hand corner.
3. (X) Draw a dotted line across the width of the insulator 1-1/2" from the bottom edge.
4. (X) Draw another dotted line across the width of the insulator 3-7/8" from the bottom edge.





Detail 2-14A



Detail 2-14B

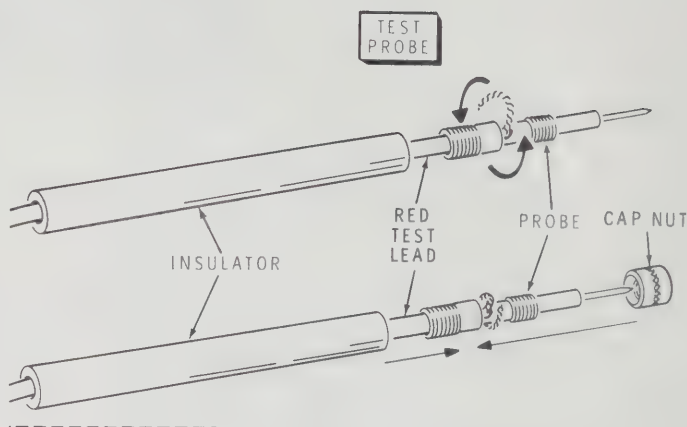
- (X) Refer to Detail 2-14B and fold the insulator on the dotted lines as shown.
- (X) Remove the paper backing from the insulator. Then place the insulator on the power transformer as shown in the Pictorial. Position the front edge of the insulator to cover the lugs on the transformer and position the wires through the cutout portion of the insulator.
- (X) Refer to the first step on Page 1-12 of Manual 9550-1 where you recorded the value of the calibration voltage. Then, record the calibration voltage on top of the insulator as shown in the Pictorial.

TEST LEAD ASSEMBLY

Refer to Pictorial 2-15 and prepare the meter test leads.

- (✓) Remove 1/2" of insulation from one end of the red test lead.
- () Install a test probe on this end of the red test lead as follows:

1. Unscrew the insulator and the cap nut from the probe tip and insert the wire through the smaller hole in the insulator.
2. Twist the fine wires together and insert them through the hole in the probe. Then form the wires around the probe and screw the cap nut over them. Screw the insulator back on the probe.



- (✓) Remove 3/4" of insulation from the free end of the red test lead.

- (✓) Insert this end of the red test lead into an input plug as shown. Then bend the wire flat against the plug body.

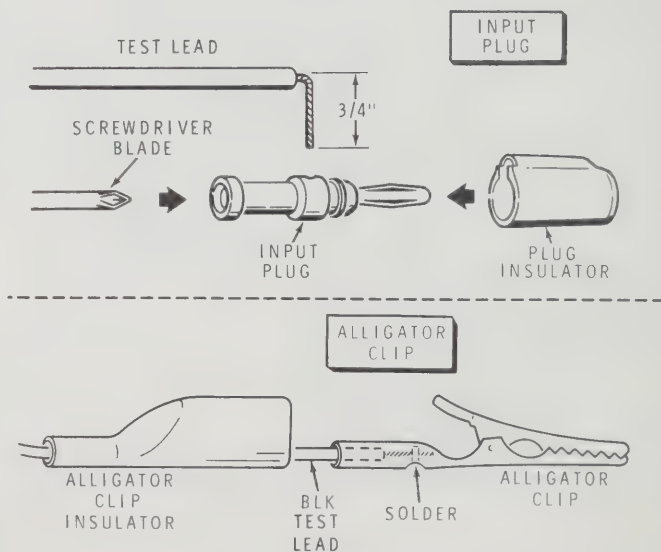
- (✓) Place the input plug on a small phillips screwdriver (or similar tool) and push a red plug insulator onto the plug and wire until the insulator snaps into place.

- (✓) Remove 3/4" insulation from one end of the black test lead.

- (✓) Install an input plug and black plug insulator on this end of the black test lead.

- (✓) Remove 1/2" insulation from the free end of the black test lead.

- (✓) Install an alligator clip on this end of the black test lead. Insert the end of the black test lead through the smaller end of the alligator clip insulator. Twist the fine wires together and insert them into the alligator clip (S-1). Slip the alligator clip insulator down over the alligator clip after the clip has cooled.



PICTORIAL 2-15

This completes the "Step-by-Step Assembly" section of the Manual. The cabinet will be installed later.

Proceed with the "Tests and Calibration" section of the Manual.

NOTE: Save any parts remaining; they will be used later.

TESTS AND CALIBRATION

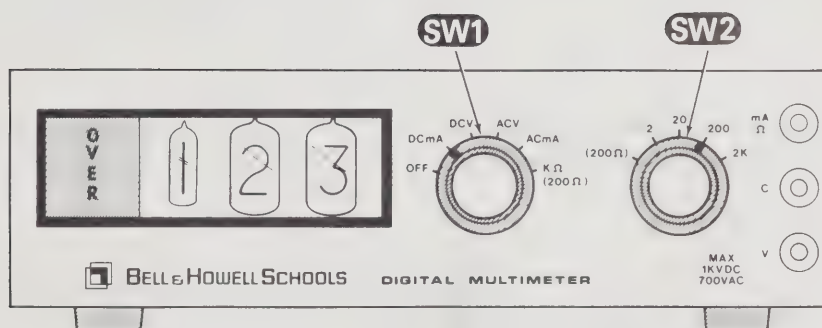


Figure 2-1

In this section of the Manual you will test and calibrate your Digital Multimeter. If at any time you do not obtain the results indicated, refer to the "In Case of Difficulty" section on Page 2-39. Locate and repair any problem before you continue with the calibration.

Figure 2-1 shows the front switches of your Multimeter. Figure 2-2 (fold-out from Page 2-29) shows the remaining controls and test points. Carefully study Figures 2-1 and 2-2 and identify the function of each switch and control.

(X) Set all ten circuit board controls to their centers of rotation.

(X) Set the front panel switches to the following positions.

SW1	OFF
SW2	2.

WARNING: When the line cord is connected to an AC outlet, hazardous voltages will be present at several places. These are shown by the boxed-in area in Figure 2-2.

(X) Plug the line cord into an AC outlet.

(X) Turn switch SW1 to the DCV position and allow the unit to stabilize for at least 30 minutes. NOTE: The two right-hand digits (displaying any number) and the decimal point to the left of the left digit should all be lit. No other lamp should be lit.

(X) Turn the ZERO ADJ control until the readout is .01. Then slowly turn the control until the readout just changes to .00. The display should change back and forth between .01 and .00.

NOTE: For test purposes, only the black test lead will be used in this section.

VOLTS CALIBRATION

Refer to Figure 2-2 for the following steps.

NOTE: You may have to perform the adjustments in the following steps more than once to obtain the proper results.

- (X) Clip the black test lead to lug 7F on switch SW1. Make sure that the free end of the red wire connected to this lug does not touch anything.

NOTE: Refer to the calibration voltage value, written on the transformer insulator, to perform the following step. Observe that the calibration voltage number has four digits, whereas the Multimeter can display only three digits. Convert the number to three digits by dropping the fourth digit if it is 4 or less, or by increasing the third digit by one if the fourth digit is 5 or more. For example:

$$1.943 = 1.94$$

$$1.946 = 1.95$$

If the value on the envelope is 2 or higher, the Multimeter OVER lamp will be lit in the following step but the 2 will not be displayed:

$$2.112 = \text{OVER} .11$$

- (X) Touch the black test lead plug tip to DC CAL TP and adjust the DC CAL control until the readout matches the value of the calibration voltage.
- (X) Remove the test lead plug from the DC test point.
- (X) Turn switch SW1 to the $k\Omega$ position and adjust the Oscillator Adjust control for a readout of "OVER .85", ± 15 digits.

NOTE: If you are unable to obtain a reading of exactly "OVER .85," obtain the nearest possible reading with the Oscillator Adjust control. Then leave the control set at this point. This reading must fall within 15 digits (that is, no less than "OVER .70" or no more than "OVER 1.00"). If you are unable to calibrate within these limits, refer to the "In Case of Difficulty" section. If your Multimeter is operating from a 60 Hz power line during calibration, the infinity display will be "OVER" and approximately 85. In the unusual case when a 50 Hz AC power line is used during calibration and the Multimeter is then used on 60 Hz AC, the infinity reading will be "OVER" and approximately 35. This is due to the count period being approximately 2 ms shorter in the latter case.

- (X) Turn switch SW1 to the DCV position and repeat the three previous steps until the correct readouts are obtained in both switch positions.

- (X) Set the front panel switches in the following positions:

SW1: DCV.

SW2: 20.

- (X) Touch the test lead tip to AC CAL TP and adjust the AC TP ADJ control (next to the AC TP) for a readout of 16.3.

NOTE: The readout may vary between 16.2, 16.3, and 16.4. A proper adjustment will cause it to read 16.3 most of the time.

- (X) Remove the probe from the AC CAL TP.

- (✓) Turn switch SW1 to the ACV position.
- (✓) Touch the test lead tip to the AC CAL TP again and allow the display to stabilize.
- (✓) Adjust the AC CAL control (at the rear of the circuit board) for a meter reading of "OVER 0.0."

NOTE: The readout may vary between 19.9, "OVER 0.0, and "OVER 0.1. A proper adjustment will cause it to read "OVER 0.0 most of the time.

- (✗) Repeat the previous two steps until the correct readouts are obtained in both switch positions.

OHMS CALIBRATION

- (✓) Turn switch SW1 to kΩ (200 Ω).
- (✓) Remove the black test lead from lug 7F of switch SW1 and clip the lead on lug 2 of fuse F1.

You will calibrate the five ohm ranges in the following steps. Touch the black test lead tip to the indicated OHMS CAL TP (test point) for each range and adjust the indicated control for an "OVER 00" readout. The decimal point should be at the indicated position.

Range Switch	OHMS CAL TP (Test Point)	Control	Meter Reading
(✗) (200 Ω)	200	200 ADJ	"OVER 00"
(✗) 2	2 k	2000 ADJ	"OVER .00"
(✗) 20	20 k	20 k ADJ	"OVER 0.0"
(✗) 200	200 k	200 k ADJ	"OVER 00"
() 2 k	2 M	2 M ADJ	"OVER .00"

- (✗) Repeat the previous five steps as many times as necessary until you obtain a stable reading for each switch position.
- (✓) Turn off the multimeter.
- (✗) Remove the test lead.

This completes the "Initial Tests and Calibration" section of the Manual. Disconnect the AC line cord from the power source and proceed to the "Final Assembly" section.

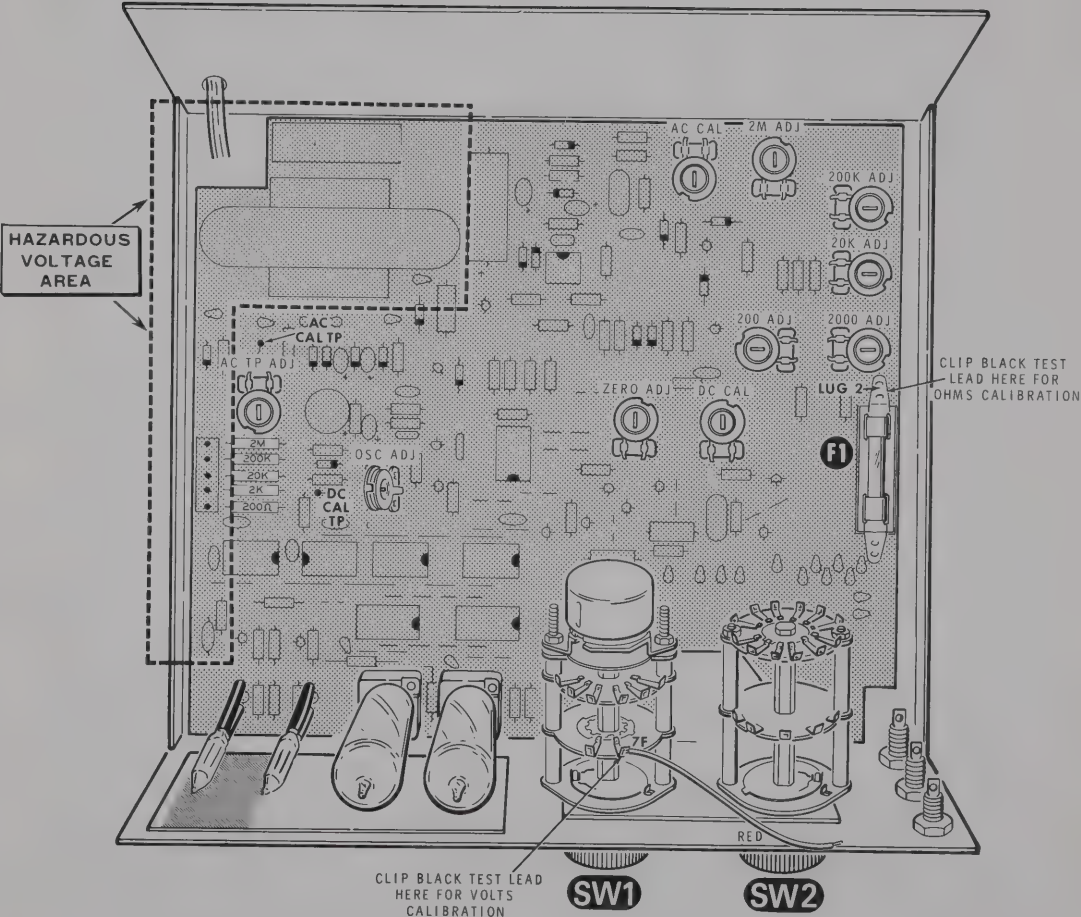
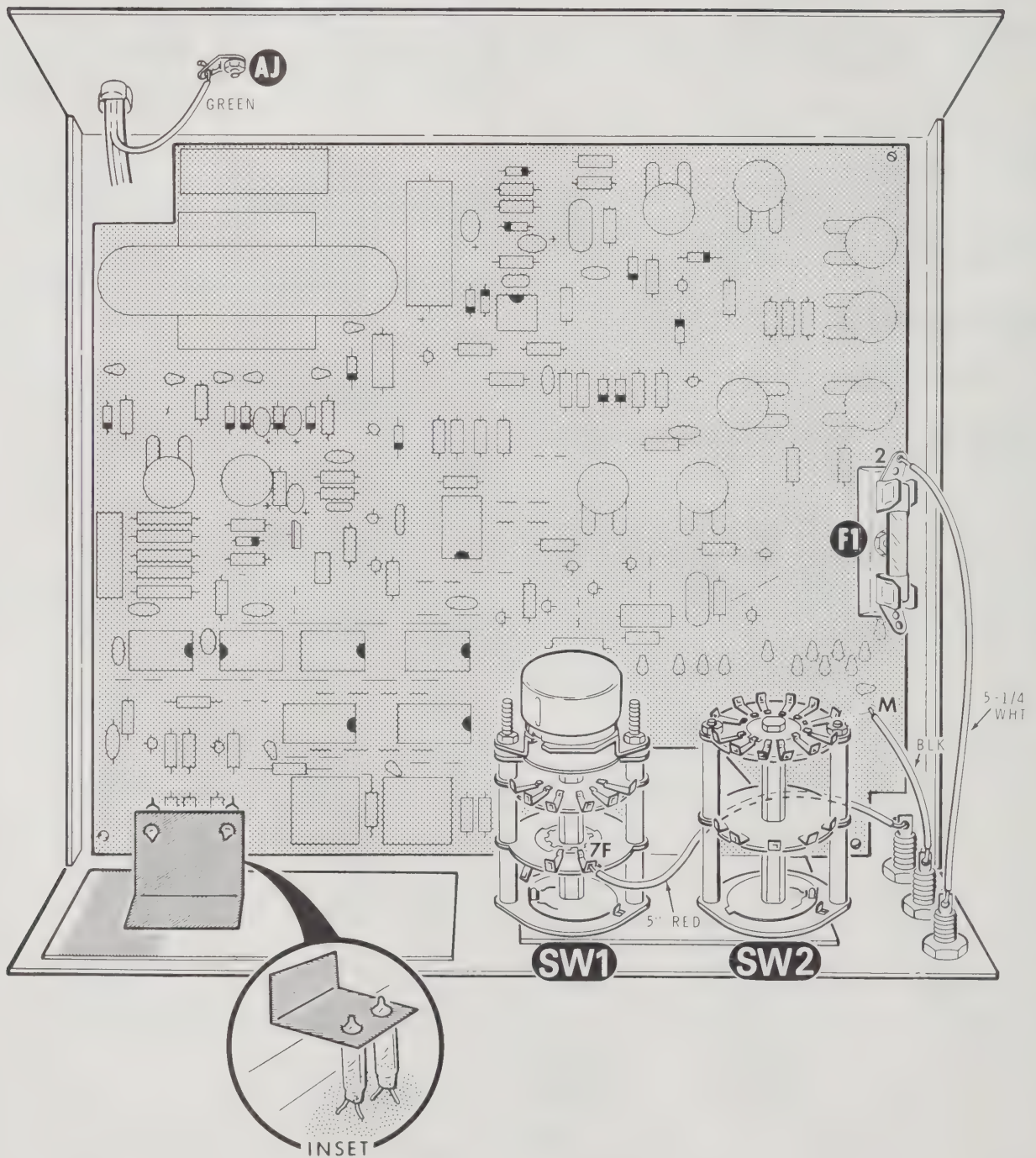


Figure 2-2

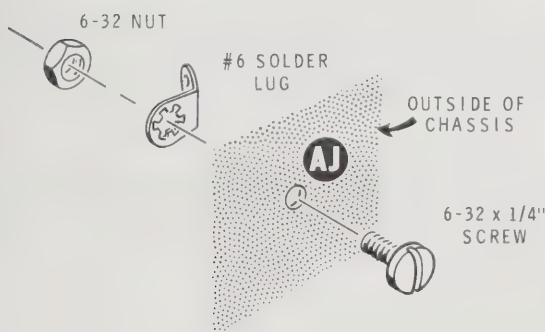


PICTORIAL 2-16

FINAL ASSEMBLY

Refer to Pictorial 2-16 for the following steps.

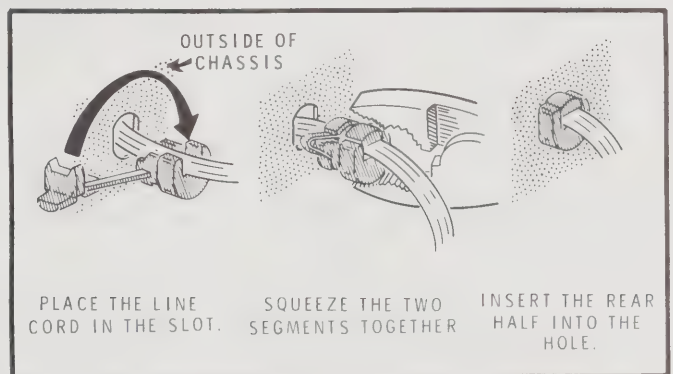
- (X) Locate the red wire coming from lug 7F on SW1 and route the free end under SW2. Then connect the free end to the red input jack (S-1).
- (X) Connect the free end of the 2-1/2" black wire coming from hole M on the circuit board to the black input jack (S-1).
- (X) Prepare a 5-1/4" white wire.
- (X) Connect this 5-1/4" white wire from the white input jack (S-1) to lug 2 of fuse F1 (S-1).



Detail 2-16A

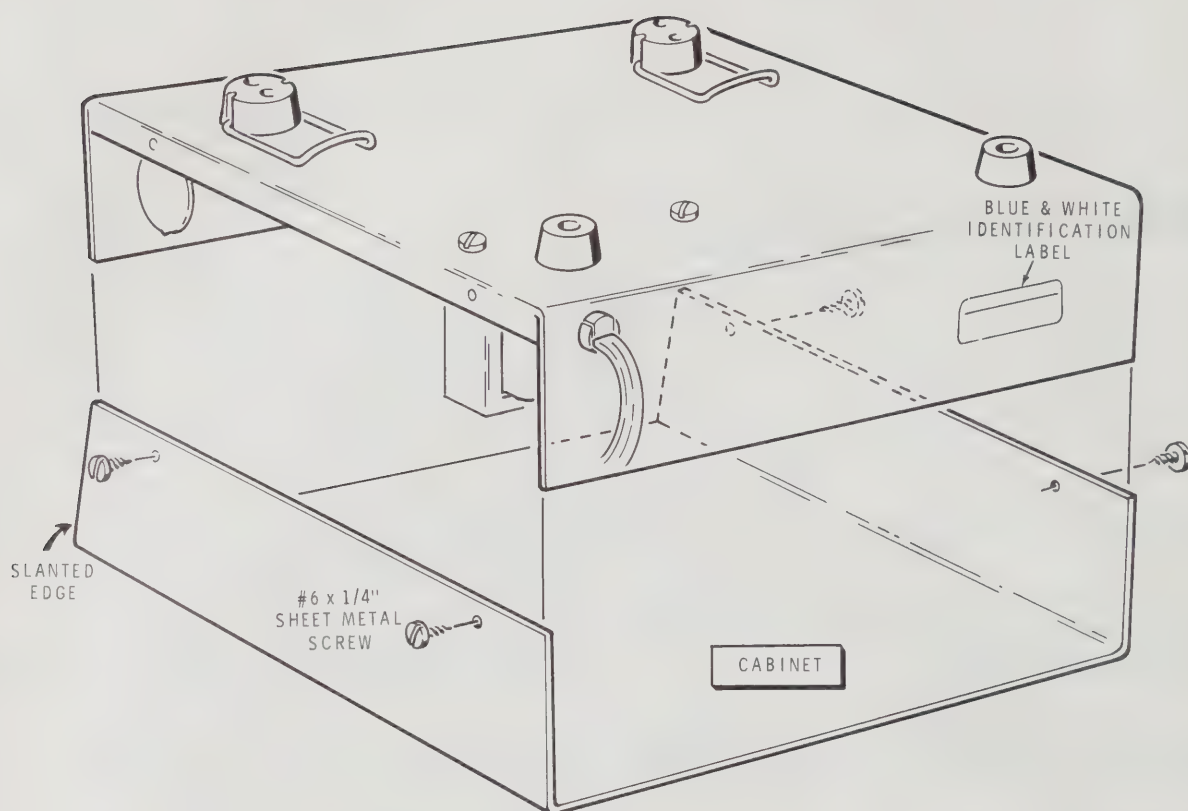
- (X) Refer to Detail 2-16A and install a #6 solder lug at AJ. Use a 6-32 x 1/4" screw and a 6-32 nut. Position the solder lug as shown in the Pictorial.

- (X) Untie the green wire from the line cord and remove 1/4" of insulation from the end.
- (X) Twist the small wire strands together and melt a small amount of solder on the strands.
- (X) Connect the green wire to solder lug AJ (S-1).
- (X) Install the strain relief on the line cord as shown in Detail 2-16B.



Detail 2-16B

- (X) Refer to the inset drawing on the Pictorial, remove the protective paper backing from the fish paper, and install the fish paper on the two neon lamps as shown. Be sure the left neon lamp is properly positioned behind the "OVER" in the window.



PICTORIAL 2-17

Refer to Pictorial 2-17 for the following steps.

- (X) Position the Multimeter down into the cabinet as shown in the Pictorial.
- (X) Mount the cabinet to the chassis with four #6 x 1/4" black sheet metal screws.

- (X) Remove the backing paper from the blue and white identification label. Then press the label into place on the rear of the chassis as shown in the Pictorial.

NOTE: Read the "Operation" section of this Manual next. Then proceed to Manual 9550-2, Part 2, and perform the Experiments.

OPERATION

DUTY CYCLE

Since the power consumption of the Digital Multimeter is very low, you may wish to leave the instrument on continuously during the daily work period. Always allow a 15 minute warmup period from a cold start to insure best accuracy.

SAFETY PRECAUTIONS

CAUTION: Always observe basic safety rules any time voltage measurements are made. Always handle the test

leads by their insulated portions and do not touch the exposed tips.

When high voltage measurements are made, remove the power from the unit under test and then connect the test leads. If this is not possible, be careful to avoid accidental contact with nearby objects which could provide a ground return path. Keep one hand behind you to minimize accidental shock hazard and be sure to stand on a properly insulated floor or floor covering. Do not switch meter ranges when high voltages and high currents are at the Meter inputs; to do so will cause switch contact arcing.

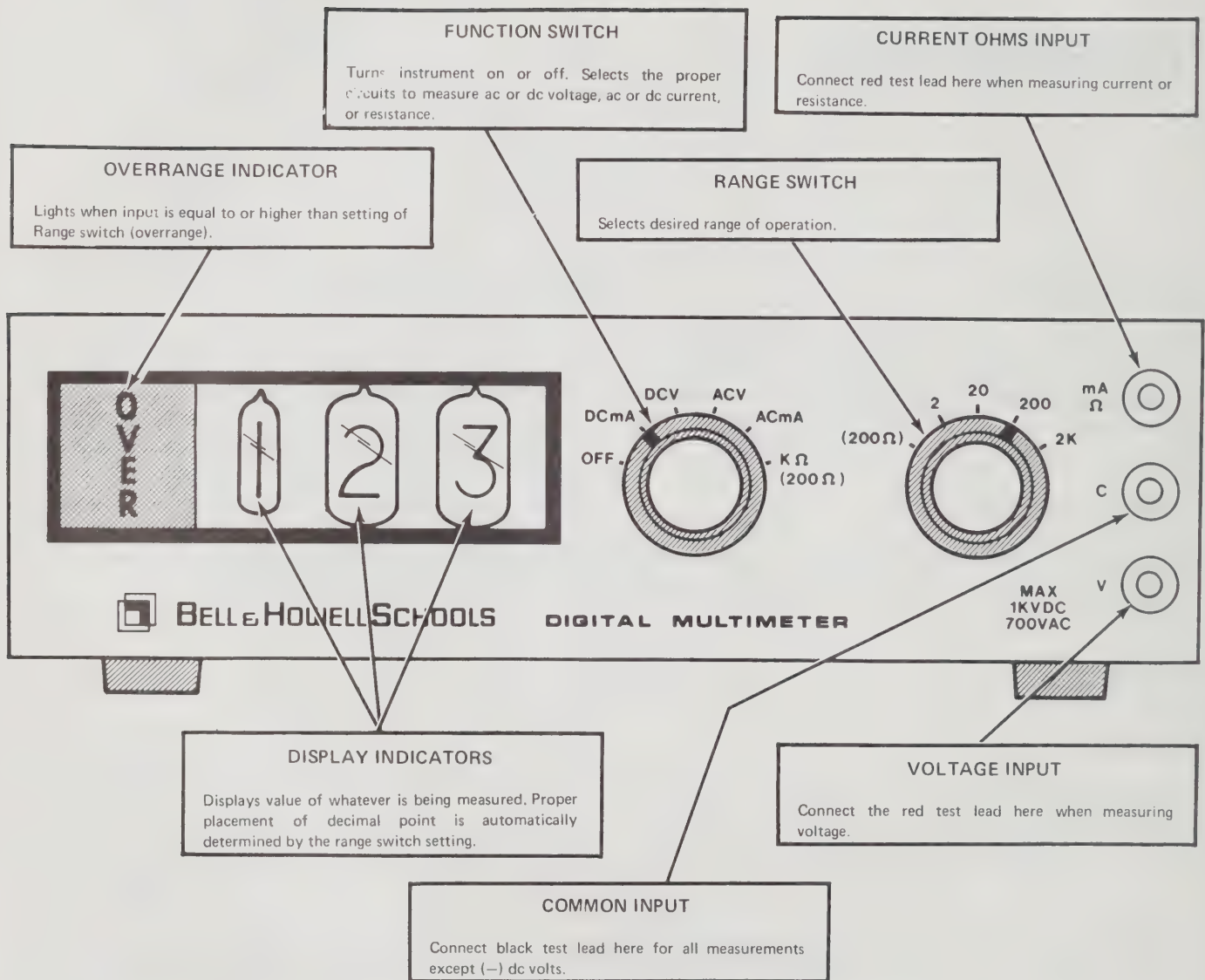


Figure 2-4

MEASUREMENTS

Refer to Figure 2-4 while you read the following information.

CONNECTING THE MULTIMETER

Place the Function switch in the OFF position.

Plug the line cord into an AC outlet.

Plug the black test lead into the C (black) jack and the red lead into the other appropriate jack (mA Ω or V).

Follow the instructions (current, voltage, resistance, etc.) according to the type of measurement to be made.

Start with the highest range and work down.

DC CURRENT MEASUREMENTS

CAUTION: 3 amperes is the maximum DC current allowable on the 2 k mA range.

1. Set the RANGE switch to 2 k or the desired lower range if it is known.
2. Set the FUNCTION switch to the DCmA.
3. Plug the red test lead into the mA- Ω jack and observe the reading. If the OVER lamp comes on, switch to a higher range immediately, as an overload condition exists. Otherwise, lower the setting of the RANGE switch until the proper range is reached. The following table indicates the readout limits for each range.

RANGE	DISPLAY RANGE	25% ALLOWABLE OVERRANGE ON ALL RANGES
(200 Ω)	Does not function on DCmA.	25% on all ranges.
2	.01 — 1.99	Over .50 (2.50)
20	0.1 — 19.9	Over 5.0 (25.0)
200	01 — 199	Over 50 (250)
2 k	.01 — 1.99	Over .50 (2.50)

NOTE: Reverse the test leads for -DC current measurements.

DC VOLTAGE MEASUREMENTS

CAUTION: Do not connect the C input to a potential greater than 500 volts above power line ground. This could damage the Multimeter.

1. Set the RANGE switch to 2 k or the desired lower range.
2. Set the FUNCTION switch to DCV.
3. Plug the red test lead into the V jack and observe the readings. Lower the setting of the RANGE switch until you reach the proper range. The following table indicates the readout limits for each range.

RANGE	DISPLAY RANGE	ALLOWABLE OVERRANGE
(200 Ω)	Does not function on DCV.	25% on all ranges except the 2 k range.
2	.01 — 1.99	Over .50 (2.50)
20	0.1 — 19.9	Over 5.0 (25.0)
200	01 — 199	Over 50 (250)
2 k	.01 — 100 (1000)	None

NOTE: To make negative (—) DC voltage measurements, reverse the test leads.

AC VOLTAGE MEASUREMENTS

NOTE: When measuring AC voltage, any input other than a pure sine wave can cause an error because the AC converter is average-sensing and rms calibrated.

CAUTION: 700 volts rms is the maximum AC voltage allowable in the 2 k range; 140 volts rms on the 2 (volt) range.

1. Set the RANGE switch to 2 k or the desired lower range.
2. Set the FUNCTION switch to ACV.
3. Plug the red test lead into the V jack and observe the reading. If the OVER lamp comes on, switch to a higher range immediately, as an overload condition exists. Otherwise, lower the setting of the RANGE switch until the proper range is reached. The following table indicates the readout limits for each range.

RANGE	DISPLAY RANGE	ALLOWABLE OVERRANGE
(200 Ω)	Does not function on ACV.	25% on all ranges except the 2 k range.
2	.01 — 1.999	Over .50 (250)
20	0.1 — 19.99	Over 5.0 (25.0)
200	01 — 199.9	Over 50 (250)
2 k	.01 — 70 (700)*	None

* Approximate rms value of 1000V peak.

AC CURRENT MEASUREMENTS

CAUTION: 3 amperes is the maximum AC current allowable on the 2 k range.

1. Set the RANGE switch to 2 k or the desired lower range if known.
2. Set the FUNCTION switch to ACmA.
3. Plug the red test lead into the mA- Ω jack and observe the reading. If the OVER lamp comes on, switch to a higher range immediately, as an overload condition exists. Otherwise, lower the setting of the RANGE switch until the proper range is reached. The following table indicates the readout limits for each range.

RANGE	DISPLAY RANGE	ALLOWABLE OVERRANGE
(200 Ω)	Does not function on ACmA.	25% on all ranges.
2	.01 – 1.99	Over .50 (2.50)
20	0.1 – 19.9	Over 5.0 (25.0)
200	01 – 199	Over 50 (250)
2 k	.01 – 1.99	Over .50 (2.50)

RESISTANCE MEASUREMENTS

CAUTION: The resistance circuits of the Multimeter are protected against the application of AC and DC voltages up to a level which would cause a current of 3 amperes.

1. Set the RANGE switch to the desired range.
2. Set the FUNCTION switch to k Ω (200 Ω).
3. Plug the red test lead into the mA- Ω jack.
4. Connect the load to the test leads and observe the reading. Raise or lower the setting of the RANGE switch until the proper range is reached. The following table indicates the readout limits for each range.

RANGE	DISPLAY RANGE	ALLOWABLE OVERRANGE
(200 Ω)		25% on all ranges.
	01 – 199	Over 50 (250)
2	.01 – 1.99	Over .50 (2.50)
20	0.1 – 19.9	Over 5.0 (25.0)
200	01 – 199	Over 50 (250)
2 k	.01 – 1.99	Over .50 (2.50)

IN CASE OF DIFFICULTY

WARNING: When the line cord is connected to an AC outlet, hazardous voltages will be present at several places. See Figure 2-2 (fold-out from Page 2-29).

Begin your search for any trouble that occurs after assembly by carefully following the steps listed in the "Visual Test" section. After visual tests are completed, refer to the "Troubleshooting Chart."

NOTE: Refer to the "Circuit Board X-Ray Views" on Page 2-51 for the physical location of parts on the circuit board.

VISUAL TEST

1. Recheck the wiring. Trace each lead in colored pencil on the Pictorial as it is checked. It is frequently helpful to have a friend check your work. Someone who is not familiar with the unit may notice something consistently overlooked by the kit builder.
2. Reheat all questionable connections to make sure they are properly soldered.
3. Check to be sure that all transistors are in their proper locations. Make sure each lead is connected to the proper point.
4. Check that each of the IC's are properly installed in their sockets, and that the pins are not bent out or

under the IC. Also be sure the IC's are installed in their correct positions.

5. Check the values of the parts. Be sure in each step that the proper part has been wired into the circuit, as shown in the Pictorial diagrams. It would be easy, for example, to install a $680\ \Omega$ (blue-gray-brown) resistor where a $6800\ \Omega$ (blue-gray-red) resistor should have been installed.
6. Check for bits of solder, wire ends, or other foreign matter which may be lodged in the wiring.
7. A review of the "Circuit Description" may help you determine where the trouble is.

If the trouble is still not located after the visual tests are completed, and a voltmeter is available, check voltages against those shown on the Schematic. Read the "Precautions for Troubleshooting" (Page 2-40) before making any measurements. **NOTE:** All voltage readings were taken with a high impedance voltmeter. Voltages may vary $\pm 20\%$.

WAVEFORMS

The correct oscilloscope waveform patterns for various points in the Multimeter are provided on fold-out from Page 2-43. To use these patterns, you will need an oscilloscope capable of the horizontal sweep and vertical sensitivity settings listed in the chart, as well as a high impedance, low capacitance probe.

PRECAUTIONS FOR TROUBLESHOOTING

1. Be cautious when testing IC and transistor circuits. Although they have almost unlimited life when used properly, they are much more vulnerable to damage from excessive voltage or current than most other components.
2. Be sure you do not short any terminals to ground when making voltage measurements. If the probe should slip, for example, and short out a bias or supply point, it is very likely to damage one or more IC's, transistors, or diodes.

TROUBLESHOOTING

Because the Digital Multimeter is fundamentally a DC voltmeter, the basic circuitry is used when the Function switch is in the DCV position, and conditioning circuits are added for other functions. Consequently, if a malfunction occurs, first check the circuitry used for the DC voltmeter function. If that is operating satisfactorily, check the circuitry added for other functions.

The following charts list malfunctions that could arise and some possible causes. Look at the "Problem" column and try to locate your difficulty. Then try to correct the difficulty by checking the "Possible Cause" column.

Use charts #1 or #2 if any malfunction should arise in the DCV position. Use chart #3 if any malfunction should arise

in any of the remaining positions. If a particular part or parts are mentioned (transistor Q2 for example, or resistor R6) as a possible cause, check these parts to see if they are incorrectly installed or wired. Check to see if an improper part was installed at that location. It is also possible at times for a part to be faulty.

Refer to the pages associated with the Schematic Diagram for IC basing diagrams and a cross reference table of manufacturers' numbers.

NOTE: Some of the circuits use IC's of the same type. An IC thought to be faulty can often be interchanged with one known to be good.

Troubleshooting Charts

The following two charts are for the DCV position. Chart #1 deals with the possibility of a malfunction that prevents the neon lamps or readout tubes from lighting or stabilizing. In chart #2, you will make measurements to check out the DCV position of the Function switch. Chart #3 is for all remaining positions.

CHART #1

PROBLEM	POSSIBLE CAUSE
Neon lamps and readout tubes do not light.	1. Power line fuse blown. 2. Diode D16. 3. Function switch in OFF position. 4. Function switch miswired.
Readout tubes light but are dim and all ten digits come on.	1. Transistor Q11 and its associated resistors, capacitors, and diodes.
A particular digit lights. However, all numerals appear dimly lit. (For example, a "3" condition always faintly lights 0 through 9.)	1. Open tube socket pin. 2. Open decoder driver pin(s).
Readout does not read 00 with inputs shorted.	1. Zero Adjust control not set properly. 2. Integrated circuit IC8 not producing reset pulse.
Readout counts up continuously.	1. Transistor Q12. 2. Integrated circuit IC8 not producing reset pulse.
Readout does not stabilize after warmup time.	1. Diode D17; transistors Q12, Q15, Q16; or an associated resistor or capacitor.
"1" or "Over" lamp comes on when inputs are shorted.	1. Transistor Q13 or Q14. 2. Integrated circuit IC5.
Two or more digits in a readout tube on at the same time.	1. Solder bridge at readout tube socket. 2. Solder bridge at IC3 or IC4 sockets. 3. Interchange readout tubes. 4. Interchange IC3 or IC4.
Oscillator does not adjust to "Over .85," ± 15 digits.	1. Resistors R206 and R208. 2. Control R207. 3. Capacitors C201 and C203.

CHART #2

RED LEAD (V INPUT) TO:	FUNCTION SWITCH	RANGE SWITCH	PROBLEM	POSSIBLE CAUSE
Black lead (C input)	DCV position	2 position	Readout does not read .00.	1. Integrated circuit IC8 not producing reset pulse. 2. Transistor Q11 and its associated resistors, capacitors, and diodes. 3. Diode D16. 4. Integrated circuit IC6 or IC7. 5. Integrated circuit IC3 or IC4.
DC CAL TP	DCV position	2 position	Readout does not read the value stamped on the voltage reference source package.	1. Transistors Q1 through Q7. 2. Integrated circuit IC2. 3. Transistor Q12, Q15, or Q16. 4. Transistor Q11 and its associated resistors, capacitors, and diodes. 5. Diode D16. 6. Integrated circuit IC6 or IC7. 7. Integrated circuit IC3 or IC4. 8. Instrument not calibrated.

CHART #3

FUNCTION SWITCH POSITION	PROBLEM	POSSIBLE CAUSE
DC mA	Readout does not seem to read correctly.	1. Resistors R101 through R109.
ACV		1. Transistor Q8 or integrated circuit IC1.
AC mA		1. Resistors R101 through R109. 2. Transistor Q8 or integrated circuit IC1.
K Ω (200 Ω)		1. Controls R111, R113, R115, R117, or R119 not adjusted properly. 2. Resistors R111 through R119, or R121 wrong value. 3. Transistor Q9 or Q10, or diode D1, D2, or D3.

OSCILLOSCOPE WAVEFORM PATTERNS

To check for the presence of waveforms shown in the chart (fold-out from Page 2-43), use an oscilloscope capable of the settings given. Set up the oscilloscope for line triggered sync and use a high impedance, low capacitance probe.

1. Set the Multimeter as follows:

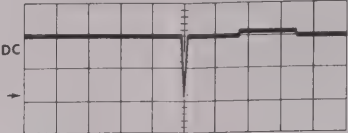
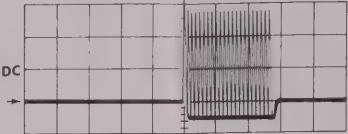
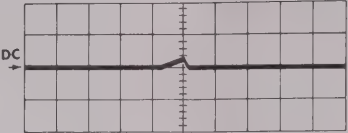
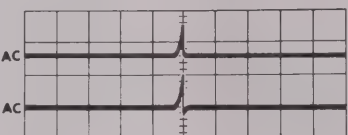
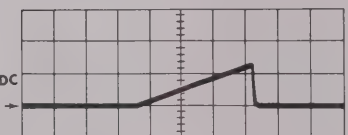
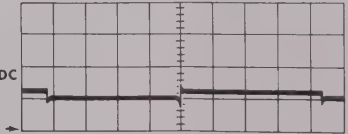
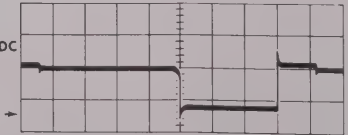
A Set the Function switch at DCV.

B Set the Range switch at 2.
2. Connect the common lead of the oscilloscope to the C input jack on the Multimeter.

3. Adjust the oscilloscope for the designated vertical and horizontal settings for the waveform to be observed.

4. Connect or touch the oscilloscope probe tip to the test point and compare the pattern to the one in the chart. If you do not obtain the proper waveform, look at the "Possible Cause of Improper Waveform" column to determine the problem.

WAVEFORMS

TEST POINT	OSCILLOSCOPE		INPUT COUPLING	Waveforms (DC zero-volt reference point indicated by arrowhead)	POSSIBLE CAUSE OF IMPROPER WAVEFORM
	Vertical: Volts/cm	Horizontal: m sec			
1 IC8, pin 11	2	2	DC		1. Pin 13 not held high (+5 VDC). 2. IC8. 3. Solder bridge.
2 IC7, pin 14 (2 VDC input)	2	2	DC		1. No signal from transistor Q15. 2. Solder bridge.
3 Q1, base (input shorted)	2	2	DC		1. Capacitor C106. 2. Transistor Q5 "on" (emitter negative to base and collector). 3. Transistor Q7.
4 IC2: (input shorted) Pin 6 Pin 12	.5 .5	1 1	AC AC		1. Pin 6: A. Transistor Q1 or Q4 (check voltages). B. Control R152 misadjusted. Pin 12: A. Transistor Q2, Q3, or Q6 (check voltages). B. Control R152 misadjusted.
5 Q1 base (2 VDC input)	2	2	DC		1. Transistor Q1. 2. Check for input to Q1 base. 3. Check meter switch positions. 4. Should be 1 MΩ from V panel jack to Q1 emitter.
6 D17 anode (input shorted)	1	2	DC		1. Diode D17. 2. Control R204 or R210. 3. IC2.
7 D17 anode (2 VDC input)	1	2	DC		1. Refer to step 6.

SPECIFICATIONS

Functions	DC volts, DC current, AC volts, AC current, ohms.
Ranges (Full Scale)	DC volts: 0-2, 20, 200, 1,000 V. DC current: 0-2, 20, 200, 2,000 mA. AC volts: 0-2, 20, 200, 700 V rms (25 Hz to 10 kHz). AC current: 0-2, 20, 200, 2,000 mA rms (25 Hz to 10 kHz). Ohms: 0-200, 2K, 20K, 200K, 2,000K ohms.
Overrange	25% on all functions, within maximum input limits.
Maximum Input	3 amperes into AC or DC mA, and Ohms (fuse protected). 700 VAC rms into Volts (except 2 V range: 140 VAC rms). 1000 VDC into Volts (except 2 V range: 200 VDC).
Resolution (low range)	Volts: 10 mV. Current: 10 μ A. Ohms: 1 ohm.
Display	2-1/2 digit numeric.
Accuracy (Full Scale ± 1 digit)	DC volts $\pm 1\%$. DC current $\pm 1.5\%$. AC volts $\pm 1.5\%$. AC current $\pm 1.5\%$. Ohms $\pm 2\%$.
Input Impedance	1 megohm on all voltage ranges. 2 V drop maximum on current ranges.
Sample Rate	Line frequency.
Power Requirements	110-130 VAC/220-260 VAC, 50/60 Hz, 8 watts.
Fuse Requirements	Input: 3AG, 3 Ampere. Line: 3AG, 1/4 Ampere (1/8 Ampere for 240 VAC).
Dimensions (overall)	3-1/4" high, 9-1/2" wide, 8-3/4" deep. (8.25 cm high, 24 cm wide, 22.2 cm deep)
Weight	5 pounds (2.3 kg).

CIRCUIT DESCRIPTION

Refer to the Schematic Diagram (fold-out from Page 2-55) while you read the following description.

To help you locate parts in the Meter or on the Schematic, the resistors, capacitors, and other components are numbered as follows:

100 — 199 and 200 — 299 Parts mounted on the circuit board.

NOTE: Transistors, diodes, integrated circuits, and tubes are numbered without regard to specific grouping.

Selected inputs of resistance, current, or voltage to be measured, are directed through the contacts of the Function switch and through the scaling networks of the Range switch to the input of the A to D (analog-to-digital) converter. Inputs other than DC volts are directed through conversion circuits. The result of switching, scaling, and conversion is that all inputs are converted to a proportional DC voltage level acceptable by the A to D converter.

The analog-to-digital converter converts the input DC voltage to a pulse count during a time period. This time period allows a clock oscillator to generate a number of pulses which are directly proportional to the DC input level. After passing through the decade divider and the decoder driver circuits, the number of gated pulses from the clock oscillator are displayed by the digital readout tubes.

BASIC MEASURING CIRCUIT

The basic measuring circuit is a monopolar analog-to-digital converter using a single ramp technique along with a stable oscillator for long-term accuracy. All inputs are converted to +DC volts before being applied to the A to D converter. Full

scale input voltage to the A to D converter is +2 volts DC, regardless of the selected function or range.

If the input exceeds 2 volts DC, it is scaled down to 2 volts or less by the Range switch before it enters the converter. AC voltages are converted to +DC by an average-sensing, rms calibrated operational rectifier circuit. When DC current is measured, a precision resistor is placed in shunt with the input to the A to D converter. For AC current, the shunt resistor is placed across the input to the AC converter. The voltage developed across the shunt resistor is thus measured, rectified if AC, and applied to the input of the A to D converter.

Resistance is measured by routing a calibrated constant current through the unknown resistance. The voltage drop developed across the unknown resistance is applied to the input to the A to D converter.

Timing for the conversion and readout circuits is controlled by the cyclic rate of the AC line frequency. The display tubes are illuminated only during the positive portions of the half-wave rectified high voltage pulses, and the A to D converter is cut off and no oscillator pulses are generated during this time. During the zero-level portion of the rectified high-voltage pulses, the readout is extinguished and a pulse is generated to reset the decade dividers to zero. Then the clock oscillator output is counted. The pulses are routed to the decoder network and applied to the readout tubes before the next half-wave voltage disables the oscillator and turns on the display tubes.

The counting and readout time is equally divided, and both times occur in slightly less than 17 milliseconds for the 60 Hz line frequency, and in 20 milliseconds for a 50 Hz line frequency. Normal persistence of vision does not permit the eye to detect the on-off operation of the readout tubes. Thus the display appears to be constant to the observer and provides a pseudo type of memory for the count.

INPUT SWITCHING

DC Current

DC current is applied to the meter through the mA- Ω jack and the C jack on the front of the Meter. After passing through contacts on wafer 1 of switch SW1, the current is routed to lugs 1 and 3. As the current passes through lug 3 and through a shunt resistor (R106 through R109 selected by switch SW2, a voltage is developed across this shunt. This DC voltage is then applied through lug 1 on wafer 1 of SW1 to the input of the A to D converter (the emitter of transistor Q1).

DC Voltage

When a DC voltage is being measured, it is routed through the V input jack to lug 7 on wafer 1 of SW1 and through the switch contacts to lug 5. The voltage is then applied to a voltage divider network on switch SW2 that consists of precision resistors R101 through R104. A DC voltage developed across this divider, proportional to the input voltage, is routed through SW1 contacts and to the A to D converter input circuit.

AC Voltage

AC voltage is routed in the same manner as DC voltage through the input switching, until it passes through the voltage divider network, R101 through R104, on switch SW2 where a proportionate voltage is developed. This scaled AC voltage is then applied to the AC converter through lugs 16 and 14 of wafer 2 on SW1. The DC output of the AC converter is routed through lugs 7 and 9, to lug 1 on wafer 2 of SW1, and then to the input of the A to D converter.

AC Current

AC current is directed through the Function switch contacts and into the shunt resistors of switch SW2, where a proportional voltage is developed, as in the case of the DC current. This AC voltage developed across a shunt resistor is applied through the AC converter in the same manner as the AC voltage previously described. The resultant DC voltage is routed to the input of the A to D converter.

Resistance

When a resistance is being measured, the mA- Ω input lead is connected through lugs 1 and 3 on wafer 1 of SW1, to lugs 12 and 22 on wafer 2 of SW1. From this point, the unknown resistance is connected to the collector of constant current source transistor Q10, through resistor R132 and diode D2. Depending on the ohms range selected by SW2, a selected calibrated resistance is placed in the emitter circuit of transistor Q10 and controls the level of the constant current through the circuit. Calibration resistances are composed of resistors R111 and R112 in the 2M circuit, R113 and R114 in the 200K circuit, R115 and R116 in the 20K circuit, R117 and R118 in the 2K circuit, and R119 and R121 in the 200 Ω circuit. A constant current passed through the unknown resistance will develop a voltage that is proportional to the value of that resistance. This voltage is then applied through lugs 1 and 11 on wafer 2 of SW1, to the input of the A to D converter.

Ohms Constant Current Source

Transistors Q9 and Q10; diode D3; and resistors R111 through R119, R121, and R137 are the main components for the OHMS constant current source. Diodes D1 and D2 are protection devices to prevent destruction of this circuit if the input leads are inadvertently connected across a voltage source. Transistor Q9 is connected as a zener diode. Transistor Q9, diode D3, and resistor R137 will maintain a constant bias for Q10, which is determined by the current through the Q10 emitter resistors (R111 through R119 and R121). The variable resistors are adjusted to allow the correct amount of current to flow through Q10 and each of the standard calibration resistors to provide a +2-volt DC level to be applied to the A to D converter for each range selected.

A 200 ohm resistor will require 10 milliamperes of current to develop a 2-volt drop across it. Therefore, resistor R119 is adjusted for a constant current of 10 mA when the Function switch is in the k Ω position, the Range switch is in the 200 Ω position, and a 200 Ω resistor is across the Ω and C input jacks of the Multimeter. Each of the remaining ohms ranges will divide the amount of constant current by ten so that as the range is decaded up, the current is decaded down to maintain a 2-volt DC level for full-scale readings on all five ranges.

AC Converter

The AC converter, which consists of transistor Q8, IC1, and the associated components, functions as an operational rectifier. The gain of the converter is such that the average rectified voltage of a sine wave will produce a DC voltage equal to the rms value of the applied input AC voltage. Capacitor C103 will prevent DC from entering the converter and diodes D4 and D5 are protection diodes to limit the input voltage for safe operation of source follower Q8 (a buffer stage). R153 is for DC stability, D8 and R154 provide negative feedback during negative inputs, and D9 and R155 provide negative feedback during positive inputs. R156 and R167 adjust the gain of IC1 to provide a DC voltage to the input of the A to D converter which is equal to the rms value of the AC voltage input to Q8. R129, R128, and C104 filter the half-wave voltage before it is applied to the A to D converter. C101, R133, and C105 give additional filtering for all inputs regardless of the function.

ANALOG-TO-DIGITAL CONVERTER

Refer to the waveshapes in Figure 2-5 (fold-out from Page 2-44) while you read the following information.

When a DC voltage is applied to the emitter of transistor Q1, the A to D converter will function as follows:

During time T1 (waveform A), the display is illuminated and the A to D converter is disabled. At the start of T2, the display is extinguished and the base of transistor Q5 goes low (waveform F). This removes the short across capacitor C106 and allows C106 to take on a charge by the current from transistor Q7, a constant current source. This charge is in the form of a ramp (waveform C).

The termination of time T1 also produces a reset pulse (waveform G) to clear the counting circuit (IC's 5, 6, and 7) to zero for the start of another count. At the end of time T2, the voltage across capacitor C106 is at a level that permits transistor Q2 to conduct, lowering the voltage at its collector. This lower voltage at Q2's collector is inverted and amplified by transistor Q6 and applied to the input of IC2, which is wired as an R-S (Set-Reset) flip-flop (see Figure 2-6). The "high" at the reset input, pin 12, produces a "low" at the $\bar{Q}$ output, pin 13. This, in turn, turns off

transistor Q3 and then transistor Q2. This forms a short start pulse (waveform D) and produces a "low" at the base of transistor Q12 (waveform J), which removes the short from clock oscillator transistors Q16 and Q15 and allows the oscillator to produce a series of pulses until a stop pulse is generated to disable the oscillator.

As an example, assume a 1-VDC input to the emitter of transistor Q1. This will cause a display of 100 on the readout tubes. When the ramp amplitude reaches the Q1 emitter voltage, plus the .6 to .8 volt forward base-to-emitter drop, Q1 will conduct and quickly lower the Q1 collector voltage. This negative - going pulse is inverted by transistor Q4, which places a "high" on the input of the Stop R-S flip-flop, pins 1 through 6 (see Figure 2-6). The output (pin 1 of IC2) of the Stop R-S flip-flop will go high and allow transistor Q5 to conduct and discharge capacitor C106. This cuts off transistor Q1 to form the stop pulse (waveform E).

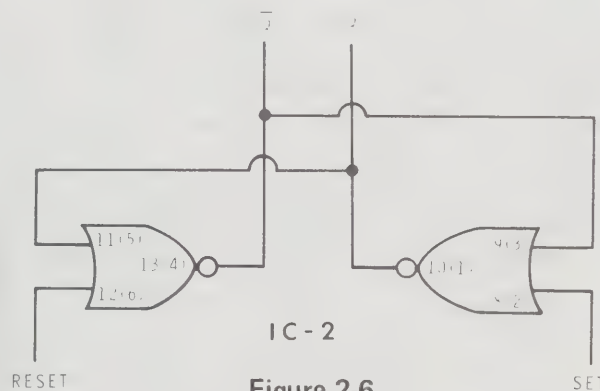


Figure 2-6

The start and stop R-S flip-flops form a latching circuit to control the switching operation of transistor Q12 (waveform J), which controls the on/off period of the clock oscillator (waveform H). The clock frequency is adjusted with R207 so that one volt of DC applied to the emitter of Q1 will produce 100 pulses at the input to the counter circuits.

BINARY TO DECIMAL READOUT

The output string of clock oscillator pulses from the collector of oscillator transistor Q15 is applied to pin 14 of decade counter IC7. In IC7 the pulses are counted, and every tenth pulse (carry pulse) is connected from output pin 11 to input pin 14 of IC6. Once again, each tenth pulse is applied from output pin 11 of IC6 to input pin 1 of IC5.

IC5 is a dual J-K flip-flop, each of which divides its input by two. This first carry pulse from pin 11 of IC6 will produce a "high" at pin 12, the Q output of FF1, allowing Q14 to conduct and illuminate DS202, the "ONE" lamp. The second pulse from IC6 will produce a low at FF1's Q output and extinguish the "ONE" lamp. The Q output of FF1 is connected to the CP input of FF2. The second pulse from the Q output of FF2 will produce a "high" at the base of transistor Q13 and complete the circuit for DS201 and illuminate the "OVER" lamp.

The reset pulse to clear IC5 requires a pulse opposite that of the two decade counters, IC6 and IC7. Therefore, the IC6 and IC7 reset pulse is inverted by IC8B before it is applied to IC5. In this manner, pulses are counted in units, tens, and hundreds in the decade counter IC's. Decoder drivers, IC3 and IC4, convert the binary count to decimal and drive the corresponding numerals in the readout tubes.

During the period in which the pulses are being coupled into the counter circuits, readout illumination is disabled by the absence of line frequency rectified pulses. When the binary information has been stored in the decoder drivers and the oscillator input is complete, the anode voltage to the readout tubes is raised to a high level and the appropriate numerals are illuminated. The repetition rate is such that the output display appears to be continuous to the observer.

POWER SUPPLY

The blue-leads winding of the power transformer, diodes D11 and D12, capacitor C114, zener diode D10, and transistor Q11 make up the regulated +5-volt DC power supply. The black lead of the transformer is the center tap for this full-wave winding and is connected to the Multimeter circuit ground. Transistor Q11 is a zener-controlled, Darlington, pass-transistor stage. The output voltage at the emitter of Q11 remains constant over a wide range of input voltage and output load and current. Diode D10 and resistors R148 and R149 are factory-selected

components which provide an accurate, near-full-scale voltage reference for DC calibration.

The +15-volt and -15-volt supply consists of a secondary winding (with yellow leads) of the power transformer; diode D13; capacitors C117, C115, and C116; resistor R158; and zener diodes D14 and D15. Because of the uniformity of the current demand, a pass transistor is unnecessary. Resistor R151 limits the current to zener diode D10. The junction between zener diodes D14 and D15 center taps the supply voltage, and references both the positive and negative voltages to ground.

The power transformer winding with the red and black leads, provides a secondary step-up voltage. This voltage enables the readout tubes to be fired at the proper time and also supplies the power for the neon lamps used to illuminate the "1", and "Over" symbols. The rectified AC pulses that control the oscillator and readout timing are derived from this circuit. The black transformer lead also connects this transformer circuit to the circuit and chassis ground.

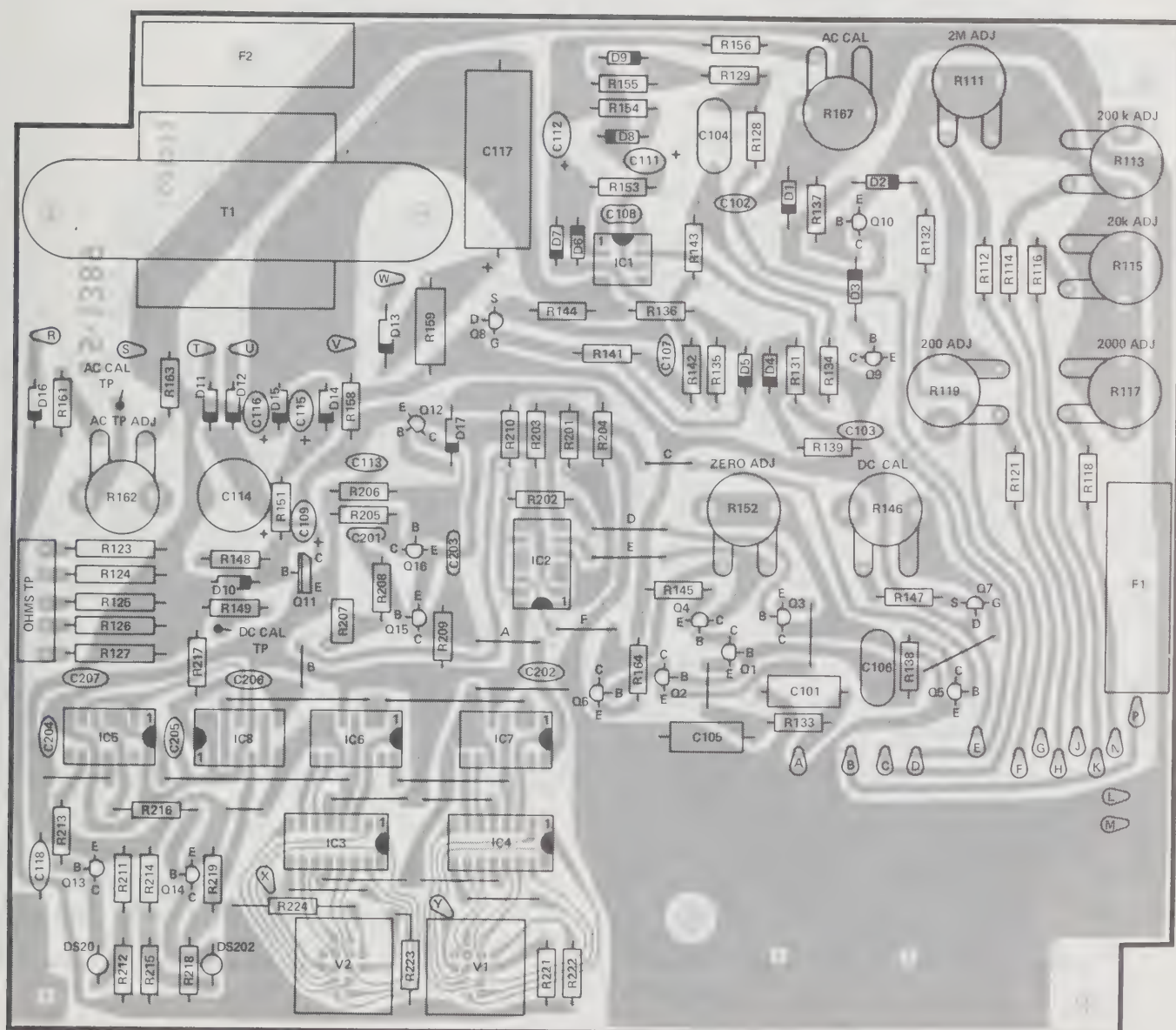
Resistors R161 and R163, plus AC TP ADJ control R162, provide the Meter with a transfer method for the calibration of the AC converter.

Resistors R218 and R219 in the pulse shaping network of IC8 form a voltage divider to attenuate the half-wave voltage to a level suitable to drive IC8.

The primary winding of power transformer T1 may be wired for a source voltage of either 120-volts or 240-volts AC, 50 to 60 Hz. Capacitor C118 connects the power line ground to circuit ground to eliminate shock hazard and to minimize A to D converter "hunt" while measuring any power line voltage or current.

Separate resistor standards on the circuit board; R123, R124, R125, R126, and R127, permit full-scale calibration of the Meter ohms ranges.

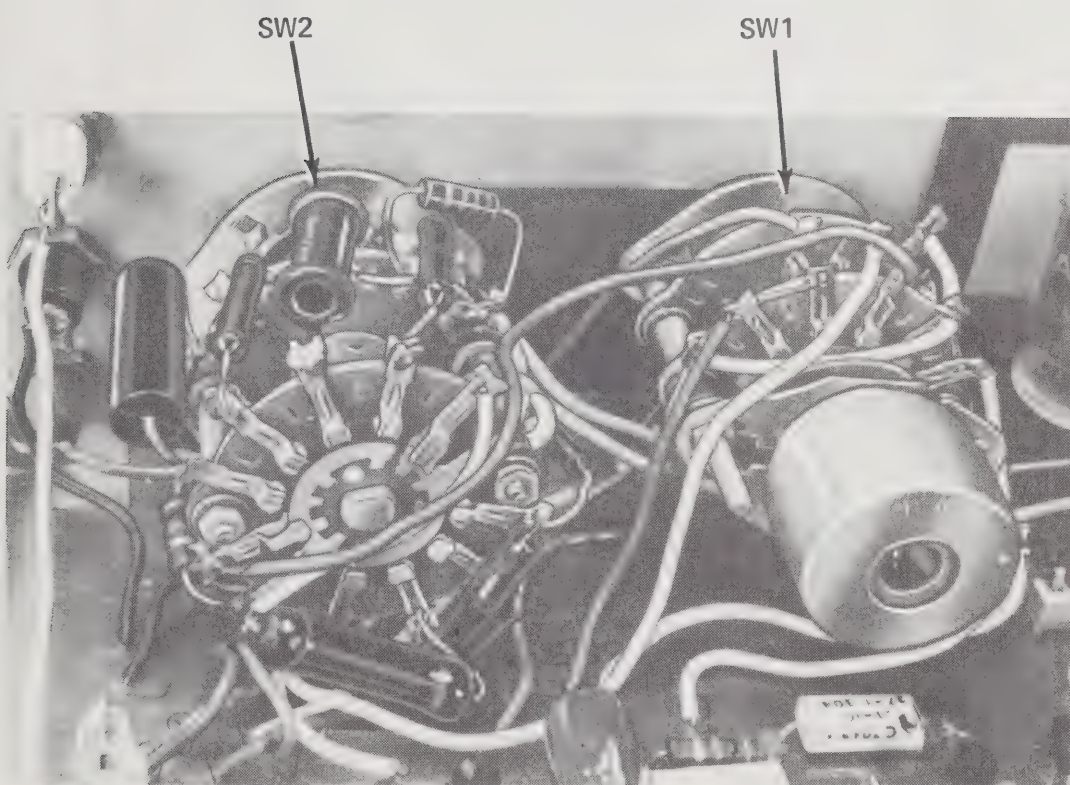
CIRCUIT BOARD X-RAY VIEWS



(VIEWED FROM COMPONENT SIDE)

(VIEWED FROM FOIL SIDE)

CHASSIS PHOTOGRAPH



TRANSISTOR BASING DIAGRAMS

COMPONENT	PART NUMBER	TYPE	CASE DIAGRAM
Q4, Q6, Q10	417-234	2N3638A	
Q11	417-272	D40C1	
Q7, Q8	417-291	2N5458	
Q2, Q3 Q5, Q9	417-801	MPSA20	
Q13, Q14	417-294	MPSA42	
Q1, Q12, Q15, Q16	417-134	MPS6520	

INTEGRATED CIRCUIT PIN-OUT DIAGRAMS

(ALL DIAGRAMS SHOWN FROM TOP)

